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TABLE OF CONTENTS.

PAGE.

The Philosophy of Christianity. By *Pliny E. Chase*..... 123
Stated Meeting, January 3..... 153
The Geology of the Lower Amazonas. By *Orville A. Derby, M.D.*. 155
Stated Meeting, January 17..... 178
Visibility of Stars in Daylight from the 1,600 foot Shaft, P. & R. R. R. Co. By *P. W. Shaefer*..... 179
Stated Meeting, February 7..... 181
Preliminary notices of an investigation on "Petrocene. By *Samuel P. Sadtler* and *H. G. McCarter*..... 185
Character of some Sullivan County coals. By *Franklin Platt*..... 186
Notes on the collection of Coins and Medals in Memorial Hall. By *Henry Phillips, Jr.*..... 191
Stated Meeting, February 21..... 206
Further confirmation of Prediction. By *P. E. Chase*..... 209
Stated Meeting, March 7..... 210
Stated Meeting, March 21..... 212
Analysis of a Calculus found in a Deer. By *Edgar F. Smith, Ph. D.* 213
Detection of Iron by means of Salicylic Acid. By *Edgar F. Smith*. 214
On the Earthquake at Aix la Chapelle, August 26, 1878. By *Henry Phillips, Jr.*..... 216
Stated Meeting, April 4..... 217
On Cordaites bearing fruit. By *Leo Lesquereux*. (Plate 1.)..... 222
Solar Records. By *Pliny E. Chase, LL.D.*..... 224
Obituary notice of Robert Frazer. By *Persifor Frazer, Jr.*..... 233
Stated Meeting, April 18..... 235
Stated Meeting, May 2..... 237
On Meteoric fireballs seen in the United States during the year ending March 31, 1879. By *Prof. Daniel Kirkwood*..... 239
Stated Meeting, May 16..... 247
On the Diamantiferous region of Paraná, Brazil. By *Orville A. Derby*..... 251
Obituary notice of Isaac Hays, M. D. By *Daniel G. Brinton, M. D.* 259

TABLE 6.	Lime Carb.	Magnesia Carb.	Insol. Matter.
(A)	95.05	2.27	2.40
(B)	63.41	28.22	7.24

but if we throw out the 5 abnormal analyses, we get the slightly different general average :—

TABLE 7.	Lime Carb.	Magnesia Carb.	Insol. Matter.
(A)	95.77	2.06	1.42
(B)	63.41	28.22	7.24

and this must be taken as the best expression of the chemical distinction between the purer and the more magnesian limestone layers of our Siluro-Cambrian (Calciferous-Sandstone) Formation, No. II, which we can make at present.

It shows plainly enough that the magnesian limestones are very far from being typical dolomites.

It shows also that the presence of magnesia at the expense of lime is connected *normally* with a high percentage of alumina silicate.

This, it seems to me, goes one step towards settling the *mechanical* theory of the origin of the magnesian carbonate on a sound basis. Although we may have to seek long for the source of the sediment, as a whole it must have a source which is common also to the clay.

Difficulties multiply upon us in studying such data. No satisfactory explanation of the bedplate structure of the mass has yet been offered. If the deposit be in the main mechanical and not chemical, it is strange that such sharp distinctions between layer and layer should have been made in the bed of a deep ocean. It is still more strange, that (on this hypothesis) strongly marked local abnormal analyses should be encountered.

This leads me to say that the above investigation is imperfect because carried on in a vertical plane only. It should now be repeated in a horizontal plane. It is desirable to learn whether the *geographical* changes may not be great enough to convert a limestone bed here into a dolomitoid there, half a mile (or perhaps 100 yards) distant. If this prove true (and the possibility of it is indicated by the abnormal analyses), then a new difficulty arises in the way of a sound theory of the origin of the bed plates ; and confuses still more any mechanical theory of the sediments.

Finally, it is evident from Table 4, that if we take 50 beds together and compare them with the 50 lying next beneath them, in other words, when we compare together two masses of the formation one or two hundred feet thick,—it is evident that, in one long age of deposit, more clay and magnesia were present in the ocean than in the preceding (or succeeding) long age.

We have then a large curve of variation, including many small curves, much more strongly marked than in the large one ; like the monthly curves superposed upon the annual path of the moon.

Were it not reckless to hazard a suggestion that the source of the magnesian element is to be sought for in some theory of the ejection and distribution of volcanic dust, so that each short time of volcanic disturbance

has left its own record in a dolomite bed,—we might proceed one step further and find in the larger differences indicia of ages of greater or less volcanism.

Daubrée in his "Synthetical Studies and Experiments on Metamorphism, &c.," says (see Smithsonian Report for 1861, page 269):

"We know that certain dolomites result from the transformation of limestone. This epigeny may be explained by the action of combinations of magnesia or carbonate of lime. There is, however, nothing to prove that this transformation into dolomite has always been produced by the same agents, and that the dolomite of Campo-Longo, for instance, with its tourmalines, corundums and various minerals, is to be assimilated with the dolomite of the other parts of the Alps and of Nice, or those which are near the deposits of calamine in Belgium.

But there are dolomites, and this is the case with the greatest numbers situated in regular beds, which are often horizontal, constituting very extensive geognostic formations. When they contain remains of testaceous mollusca the shell has disappeared; they are often crystalline and riddled with holes in such a way as to suggest a substitution. It is possible that the principal part of these last dolomites was directly precipitated. But on account of the disappearance of the shells we must admit, with Elie de Beaumont, that this second case allies itself with the first, by the reaction which the medium has exerted on the matter precipitated, a reaction of such a kind that the carbonate of lime has disappeared. Indeed we notice that pure limestone never alternates with them."

This is certainly not the case in respect of the 115 beds of our section; for certainly the limestone beds of Table 7 (A), page 121 above, with only 2 p. c. carb. mag. and 1.4 p. c. insol. matter, have a right to be classed with pure limestones.

The disappearance of shells by solution is not one of the noticeable features of the limestone strata under discussion in this paper; and they do not, as a rule, exhibit any cavities assignable to such a cause. They are non-fossiliferous, not because of the destruction of fossils, but because of the absence of large forms of life in the original sediments.

The researches of Mr. E. T. Hardman, of the Geological Survey of Ireland, published in No. 7 of the Proceedings of the R. Irish Academy, Vol. II, Ser. II, Jan. 1877, valuable as they are, give us little assistance, because his specimens were taken from the walls of caverns in cavernous limestones, where metasomatic action was in open activity.

In the Jahrbuch der K. K. Geol. Reichsanstalt, XXV, 1875, p. 293, MM. Doelter and Hörnes discuss the subject and assign 1. to the slightly magnesian limestones a directly organic origin; 2. to sporadic normal dolomites a later metamorphosis by percolation; 3. to the largest part of the dolomitoid rocks an original organic origin, with subsequent change of the fossils by magnesia salts during or shortly after deposition, and still later local lixiviation and concentration.

The Philosophy of Christianity. By Pliny Earle Chase, LL.D., Professor of Philosophy in Haverford College.

(*Read before the American Philosophical Society, February 7th*, 1879.)

Job xxviii, 12-28.

Philosophy is "the love of wisdom."

The Philosophy of Christianity is the love of Divine Wisdom. Its corner-stone is the maxim of John: "In the beginning was the Word, and the Word was with God, and the Word was God."

The capacity and the love of investigation are both due to the fact that "there is a Spirit in man: and the inspiration of the Almighty giveth [him] understanding."

In many of our colleges there is a literary society, in which the requisite qualification for membership is distinguished scholarship. It is designated by the three cabalistic letters Φ B K, which are the initials of the Greek words, *φιλοσοφία βίου κυβερνήτης*, "philosophy the guide of life."

The Christian philosopher, while recognizing the importance of correct guidance in matters pertaining to our present transitory life, attaches the greatest value to the life everlasting. He therefore accepts as his highest rule of faith and practice, both for time and for eternity, the saying of his Master: "this is life eternal, that they might know thee, the only true God, and Jesus Christ, whom thou has sent." Not simply that they might believe, but that they might know; that the eternal verities of life and immortality have been brought to light through a divinely appointed and divinely anointed Messenger, so that "he may run that readeth" them.

This claim may seem presumptuous to those who have been accustomed to look upon physical science as the only guide to certainty, and who have thought of religious belief as the result of education and circumstance, as something beyond our control, something for which we are in no way accountable and which is, therefore, of little comparative consequence. But the Christian, aware of the influence of belief upon character, feels that there are many things to be feared from faulty belief, while there is nothing to be feared from the clear and absolute knowledge of truth.

The Apostle to the Gentiles exhorted the brethren to "prove all things; hold fast that which is good." He did not, however, limit himself to "things seen" or to logical deductions from the temporal experience in which all men alike participate, although he showed himself to be a formidable antagonist in every arena of disputation. He saw that the search for truth may be prosecuted in two directions: first, in the direction of dependence, under a teachable spirit, waiting and seeking for enlightenment, and rewarded by the satisfaction of religious want; second, in the direction of independence or self-assertion, under a more haughty and confident spirit, forgetful of the sources as well as of the limits of knowledge, devising philosophic or scientific systems. In the field of inquiry to which he was especially devoted, he admonished the followers of that which is good to

"rejoice ever more. Pray without ceasing. In everything give thanks. * * * Quench not the spirit. Despise not prophesyings."

These different directions of investigation give differences of character to the results of investigation. Philosophy is not religion; neither of these important pursuits can fill the place of the other; each may, however, help the other. Philosophy is a study, religion is an instinct; philosophy is theoretical, religion is practical; philosophy is a doctrine, religion is an experience. A religious philosophy is better than a godless philosophy, because it looks at truth under more varied relations. A philosophical religion is better than a fanatical religion, because it is in harmony with all the mental faculties. But a philosophy which seeks, on the authority of a supernatural revelation, to fetter the intellectual interpretation of the physical universe, narrows the mind, while it checks the intellectual and moral progress which are important ends of religious teaching; a religion which is limited to the acceptance of philosophical inferences, may satisfy an indolent æsthetic curiosity, but it lacks the earnestness and enthusiasm of a living faith which impels its possessor to a steadfast continuance in well-doing, a faith which shrinks from no obstacle and welcomes martyrdom in preference to a surrender of its convictions.

"The fear of the Lord is the beginning of wisdom." This truth was recognized by Auguste Comte, the advocate of so-called Positivism, when he taught that intellectual development is, first, theological; next, metaphysical; and lastly, positive. A thousand years before the Christian era, David and Solomon had taught the Jews, and Buddha had taught the Hindoos, the vital doctrine which Comte distorted and corrupted, but they were not like Comte, so foolish as to remove the corner-stone after building the superstructure. They did not believe that the science of phenomena was more positive than the knowledge of God and the knowledge of principles, or that a system, which was founded in error and which continually added error to error, could finally culminate in "positive" and unquestionable truth.

Five hundred years after those early sages had directed the attention of lovers of wisdom to the beginning of wisdom, the disciples of Zoroaster in Persia, of Confucius in China, and of Pythagoras in Greece, participated in the wide-spread reformatory movement, which accompanied the restoration of Jehovah-worship at Jerusalem and the settlement of the Old Testament canon under Ezra. They prepared the way for Socrates, who, like Pythagoras, shrank from the seeming arrogance which was involved in the title "sophist," or wisest, and claimed to be merely a "philosophos," or lover of wisdom. Even the sophists generally regarded theology as the highest science. Socrates, agreeing with them in this estimate, believed himself to be a special ambassador of God to the citizens of Athens, acting under the continual guidance of a *daimon*, or divine influence, which kept him from falling into error.

Another semi-millenium beheld the birth, in Bethlehem of Judea, of a teacher whose words were received, by his disciples, as coming with an

authority such as had never been known before. Claiming to be the anointed leader for whom the Jews had long been looking, representing his mission to be the fulfilment of "the law," which was "a shadow of good things to come, and not the very image of the things," he sought not to destroy aught that was good or true in previous systems. Still pointing to God as the source of all truth and all power, still finding the highest wisdom in the great truths of religion, he counted all earthly knowledge and all earthly possessions as dross in comparison with the heavenly inheritance. "For what shall it profit a man, if he shall gain the whole world, and lose his own soul?"

We thus see that in all the most highly civilized nations of antiquity the wisest men, almost without exception, believed in some means of communication between man and his Maker, and looked upon the ministers of religion as the special recipients of divine oracles. The true followers of Jesus of Nazareth have uniformly claimed that their system of religion is the highest system that has ever been promulgated, appealing both to the intrinsic excellence of its doctrines and to the results of their lissemination for evidence that their claims are well-grounded. They may, therefore, naturally regard the Philosophy of Christianity as the highest of all philosophies, and as the most profitable study to which human attention can be directed.

Christ himself, although he taught "as one that had authority, and not as the scribes," gave continual evidence of great personal modesty and humility. Although never derogating in the slightest degree, from the conscious dignity of his divine mission, he often rejected the flattering tributes with which his disciples sought to honor him, directing them to the Father whose will he came to accomplish. He did not even attempt to found a church or to frame a consistent system of doctrines during the time of his own ministry, but he left his hearers to make such application of his teachings as would best satisfy their various individual needs and promote their spiritual growth. The wisdom belonged to him; the philosophy to his disciples. His gospel, "good tidings of great joy," was the announcement of a Saviour, who should "save his people from their sins." His purpose was neither to destroy nor to change the divine methods of education, but to fulfil typical prophecies; to throw a stronger light upon the relationships of man to his Maker; to temper personal independence by a clearer sense of personal responsibility; to communicate a knowledge of the personality of God, His personal interest in His intelligent creatures, and the personal help, which He vouchsafes to all who feel a need of help and are willing to accept it. Free grace and free will; the offer of all requisite guidance; the power of choice whether the guidance shall be received or rejected; the voluntary assumption of all the risks which may attend a wrong exercise of the choice; and "the way of salvation" through him in whom "dwelleth all the fullness of the Godhead bodily;" such are some of the chief lessons of Christianity.

"Blessed are they which do hunger and thirst after righteousness: for

they shall be filled." All nature teems with the evidence of physical adaptations to physical needs. Those who are spiritually enlightened will find still stronger evidence of abundant provision for all spiritual needs. The daily bread for which we are taught to pray is indeed the "bread of life," the bread which will satisfy to the uttermost all the hungering both of body and of soul. The Father who feedeth the fowls of the air, providing for the wants which He has implanted in His humblest creatures, is not unmindful of the more important wants of the being who was made in His image, and who was endowed with "dominion over the fish of the sea, and over the fowl of the air, and over every living thing that moveth upon the earth."

All true philosophy, Christian philosophy in an especial manner, is always cautious, teachable, longing for greater knowledge and greater faith, glad even to welcome reproof when it tends to the correction of mistakes. It looks towards the infinite as well as the finite, towards the absolute as well as the relative, towards the unknowable as well as the knowable, under a conviction that even where it cannot hope for a full satisfaction of all its longings it may gain strength by wrestling with difficulties, and with the unhesitating assurance that the higher its aims the more profitable will be its victories. While modestly acknowledging the limitations which have been imposed upon it, it answers the fundamental questions,—(a) What? (b) How? (c) Why?—by asserting (a) the possibility of knowledge, (b) by means of consciousness, (c) because the Creator of man's consciousness designed it for the acquisition of truth.

Any intimation of a possibility that human power, human wisdom, or human design may be the highest power, or wisdom, or design in the universe, or any hesitation to deny such a possibility, the Christian philosopher regards as an unfortunate manifestation of ignorance. Such ignorance may be excusable in those who are honestly seeking for truth in other directions, and wherever it exists it is the part of true modesty to acknowledge it. But if the ignorant man should try to impose his ignorance upon others, as an insurmountable barrier to knowledge, or if the Christian should hesitate to affirm the absolute and undeniable truth of his answers to the three essential questions of philosophy, no pretense of modesty could shield him from the charge of blasphemous arrogance.

Every philosophical or religious system which has any claim to consideration, must have its dogmas; its positive convictions; its formulated truths or articles of belief;* its "necessary expression in ideas, of the feelings and moral and spiritual laws and conditions which the unity and relationship of heart, conscience, will and intellect in many require should be maintained."† Such dogmas, instead of setting aside the Baconian methods, are the most obvious results of observation and experiment and legitimate logical deduction. But while dogmas are useful, dogmatism, in the sense of arrogant assertion and with a denial of any of the

*Krauth-Fleming. *Vocab. of the Philos. Sciences.*

†H. W. Bellows.

rights of critical investigation, is unphilosophical and suicidal. The nescient or "agnostic" philosopher has the same right to approach any truth whatsoever from his side, as the Christian has from his. The discoveries of each may become greatly helpful to the other, and by joint cooperation they may both, at last, attain to a broader generality of apprehension than either could have gained alone. The Christian's start, from positive knowledge and justifiable assertion, has, however, an immense advantage over his opponent's ignorant groping in the dark and despair of satisfactory attainment.

The dogmatism of science involves greater inconsistencies and is, therefore, more unreasonable than the dogmatism of religion. The modest positivist, when he stigmatizes the popular faith as an outgrown and worthless garment, a "*caput mortuum*," is urged by a spirit of the same kind as the bigot, when he bespeaks, for any form of truth-loving research, the ban of fanatical outlawry, the "*odium theologicum*." But the modesty which doubts its own capability of attaining any higher assurance than that of sense, has no excuse for theorizing, or for claiming assent to anything which is not attested by undoubted sensible evidence. The bigoted enthusiasm, on the other hand, which rests in a blind unreasoning faith and believes that any contravention of its prejudices may be followed by endless misery, is impelled, as if by a natural instinct, to the immediate adoption of such measures as seem most likely to avert a calamity which it so greatly dreads.

Notwithstanding all the teleological consequences which are implied in the admission, probably there are few, perhaps there are none, who would be unwilling to grant that the forces, which man uses for accomplishing his limited purposes, are the same as God uses for accomplishing His unlimited purposes. The Christian philosopher finds it no less evident that the knowledge and designs of the Creator, however much they may differ in degree, do not differ in their essential characteristics from the knowledge and designs of intelligent creatures; he is, therefore, at a loss to understand the difficulties which many persons honestly avow, in recognizing the manifold evidences of an All-wise, as well as Almighty Ruler, who is always "upholding all things by the word of his power."

May not a principal source of those difficulties be found in the hesitancy of a too skeptical spirit? Doubt is very good in its proper place and within proper bounds; obvious errors should certainly be avoided; novel and startling theories should not be accepted until they have been tested by the most searching and conclusive scrutiny; it may even be well to indulge in an occasional exercise of critical acumen upon possible mistakes, which may have crept into popular creeds, either through the supposed teaching of a popular leader, or through some enigmatical and perhaps accidental inadvertence. But the detection of a petty error is of far less consequence, while it may require a much greater outlay of time and ingenuity, than the grasp of an important truth. The philosopher may safely presume that any belief, which has withstood, for ages, the attacks of cavilers, must

have some solid groundwork of truth. He can make the truth his own only by fully understanding it, but he may often find satisfaction even in a partial comprehension of doctrines which have given intellectual strength and comfort to many generations of deep thinkers. He will surely gain more wisdom by a diligent looking after truth than by a sharp and cynical search for error.

Paul's advice is well supplemented by Peter's: "But sanctify the Lord God in your hearts: and be ready always to give an answer to every man that asketh you a reason of the hope that is in you, with meekness and fear." The advantages of high ideals have been recognized in all ages. When every throb of our spiritual lives is accompanied by a feeling of God's presence, the perceptive, as well as the imaginative faculties are quickened, and our enlightened insight penetrates intuitively to reasons, both of hope and of complete assurance, which a materialistic philosophy could never find and could never understand.

All philosophy must necessarily be based upon human nature. Our love of wisdom can only extend to what we can recognize, however dimly, as manifesting wisdom; our capabilities of knowledge are limited by our capacities for knowledge.*

The mathematical necessity which requires that all Consciousness should be manifested under the three primary relations of Motivity, Spontaneity, and Rationality, is tacitly recognized in the modern classification of mental faculties as Presentative, Representative, and Intuitive. This subjective aspect of our spiritual nature finds objective intellectual satisfaction in systems of Religion, Morals and Science.

The subjective exercise of Consciousness, in the primary relations or faculties, is manifested in Feeling, Will and Thought, which are indications of objective Need, Power, and Purpose.

Both the aim and the goal of Consciousness are subjectively developed in Faith, Desire, and Understanding, which find complete objective provision in Revelation, Sanctification, and Inspiration.

If we designate the Motive, Spontaneous and Rational forms by the symbolic letters M, S, R, these relations may all be readily grouped, as in the following synopsis:

Subjective.

M.	S.	R.
R. Presentation.	Representation.	Intuition.
S. Feeling.	Will.	Thought.
M. Faith.	Desire.	Understanding.

Objective.

M.	S.	R.
R. Religion.	Morals.	Science.
S. Need.	Power.	Purpose.
M. Revelation.	Sanctification.	Inspiration.

Consciousness is the surest of all things. It is, therefore, unphilosophical

*See Trans. Soc. Phil. Amer. xii, 494-5, 468-73.

to try to trace its origin to material or unconscious substance, of which nothing can ever be known, except the qualities which Consciousness itself attributes to the supposed occasion of its own least important experiences. The conviction of material reality is, however, so strong that we should accept it as a matter of instinctive belief, and, therefore, as a truth of inspiration.*

Since thought is stimulated directly by will, Reason is apt to believe herself independent, and to forget that all her powers, as well as all the facts and premises upon which she exercises those powers, are given by the Creator for the special uses which he designed. Scientific investigators often forget that they can reach truth only so far as it has been divinely "unveiled" or revealed, and that all error is the result of too great confidence in the unaided strength of imperfect human reason.

All the needful revelation that man has been able and willing to accept, has been offered to him, in all ages. In order that he may derive the greatest possible help from the offer it is necessary that his will should be wholly given up to the divine will. "They that wait upon the Lord shall renew their strength." This waiting should not be confined to the religious instincts. It is no less important in the training of the will and in the enlightenment of the reasoning faculties. The inspiration of "unconscious cerebration," during the quiet watches of the night, often untangles a knotty clue which has led the self-asserting mind into a labyrinth of desperate perplexity; the sanctification, which rewards the opening of the door to the Saviour who stands and knocks, always leads to a "change of heart" and often transforms the habitual character in a way that may be rightly regarded as miraculous; the inshining light of immediate revelation gives a clearness of vision and a certainty of knowledge which are known only to those who have rightly learned both to open and to use their spiritual eyes. In every case willingness must accompany ability. Help is never forced upon us; if we choose to trust solely to our own delegated strength, we are free to do so and we may often make valuable attainments in so doing, but if we wish most fully to appropriate the prophetic assurance, "the crooked shall be made straight and the rough places plain," we must feel the need of help, and be willing to seek for it where alone it is to be found.

Christian philosophy discards the use of none of our faculties; on the contrary, it is the only philosophy which insists on the right development of them all. Scientific writers often speak as if nothing should be left to faith, but everything should be decided by reason. The Christian, while committing himself to nothing that is unreasonable, places faith above reason, and sees that reason always errs when faith is discredited. The most implicit faith is always given to that which is self-evident to the believer; his faith in what he believes to be self-evident to others comes next in order and is hardly less confident. The man who should attempt, by any reasoning process, to prove what is self-evident, or even to make it plainer than it is

* Loc. cit. pp. 495-503; 467-8; 504-34.

already, would only show himself to be one "that darkeneth counsel by words without knowledge."

All knowledge must not only begin in faith, but it must also proceed by faith, end in faith, and rest on faith. So long as our faith is weak in the full self-evidence, of our premises, of their logical connection, of the legitimacy of our reasoning faculties, or of their rightful exercise, all our inferences will be vitiated by doubt; we may reach some degree of probability, but no certainty. Of these reasonable requirements the legitimacy of our reasoning faculties underlies all the others. We can have no other reasonable assurance of that legitimacy than our conviction of the wisdom and truthfulness of the Author of our being. The highest faith is, therefore, religious faith; the highest religion is the one which offers the most satisfactory provision for all the spiritual needs of man, in all ages and under all circumstances.

None of our faculties have been made in vain. If the human race, in its infancy, was more given to theology than it is in the present day, its devotion was due to a greater sense of its needs. If the devotion led to any exaggerated development of a faith which looks to eternity, who will say that it displayed less true manhood than like exaggerations of a reason which looks only to earthly temporalities, and prides itself in "oppositions of science falsely so-called?"

True science will not only gladly accept, but it will even eagerly seek, all the help that it can get from every quarter. Assured of the perfect harmony of all truth, and of its many-sided relations, it will see that no truth can be fully understood until it has been studied in its several primary bearings on the triform intelligence of man; that the proper culture of intelligence looks to a complete and symmetrical growth instead of a monstrous, distorted, one-sided growth; that the loftiest revelations of faith yield the most soul-satisfying food for "the scientific uses of the imagination;" that the most complete sanctification of desire is attended by the greatest earnestness of purpose; that the fullest inspiration of understanding is shown by the clearest recognition and the most cheerful acknowledgment of the divine origin of the inspiration; that the dicta of all the mental faculties should be accepted, compared and reconciled, so as to give the broadest possible views of truth; that whenever inclination or avocation give the mind a special bias in one direction, special pains should be taken to learn what religious, moral or scientific acquirements are needed in order to maintain the equipoise of perfect manhood.

God's revelations in the book of nature, are as old as creation. Man, after the lapse of thousands of years, learns the alphabet, spells out a few of the simplest sentences in the record, and sets himself up in the pride of his new attainments, as the intellectual lord of the universe. He forgets that the lesson must have been set before it could be learned; that it may be learned sooner by those who are ready to listen to the Teacher, than by those who try to pick it out by themselves; and that it is never learned without the Teacher's help, although the help may be so skilfully given that the scholar is not aware of it.

The cheerful recognition of the intimate connection between religion and wisdom, was not confined to the early sages. In all historical times the wisest men have felt and acknowledged that it was their highest aim and their highest privilege to read and comprehend even the simplest thoughts of God. The boasted intellectual progress of the last three centuries is rightly credited, in large measure, to Bacon's revival and skilful unfolding of the inductive method; but the religious reformations of Wiclif and Huss and Jerome and Luther had preceded Bacon and prepared the way, through clearer expositions of heavenly truth, for a fuller understanding of worldly truths. Comte attacked theology and metaphysics, at the outset of his career, with Quixotic zeal and Quixotic blindness; but he ended by deifying humanity as a fit object for the worshiping instinct of man, and by promulgating a system of more arrogant metaphysics than ever bewildered the followers of the haughtiest Grecian sophist. The leaders of scientific thought in our own day, with few exceptions, are believers in God; many of them, perhaps a larger relative number than at any earlier period, are also devout believers in Christian revelation, and their belief is more weighty because it is not merely traditional, but springs from deliberate examination and conviction. The godless theories and ungodly lives which degrade humanity are due to the ignorance of smatterers, not to the teachings of earnest and hardworking investigators.

Christianity, more thoroughly than any previous system, teaches the essential identity of secular and sacred truth. To the Pharisees who would fain regulate all observances by their own narrow interpretations of religious doctrines, it says: "The Sabbath was made for man, and not man for the Sabbath;" to the Greeks who ignorantly worshiped the Unknown God, it says: "For in him we live, and move, and have our being;" to those who needlessly embitter their lives by over-anxious thoughts for the morrow, it shows the providence of the Father who watches over the ravens and the sparrows and the lilies and the grass of the field; to those who would set up their own pride or prejudice as a standard of merit, it says: "What God hath cleansed, that call not thou common." It invests all days, all acts, all thoughts, all pursuits with a holy dignity, so far as they may be made tributary to the highest welfare of a single individual, and inculcates full consecration in the injunction "Thou shalt love the Lord thy God with all thy heart, and with all thy soul, and with all thy strength, and with all thy mind."

While truth is one, interpretation is legion. Difference of interpretation does not necessarily imply error in any of the holders of views which may appear to be irreconcilable, unless we regard all partial truth as actual error. Imperfect beings can only gradually be brought towards perfection; in their upward growth an endless variety of shortcomings may need an endless variety of helps, and the truth which is most helpful, in consequence of the greatest number of possible unfoldings, is, for that very reason, the highest truth.

If we extend the definition of Reason so as to embrace in its province

all departments of knowledge, we may designate its three primary subdivisions as Pure Reason, Practical Reason, and Logical Reason.

Pure Reason corresponds pretty satisfactorily to Kant's *Reine Vernunft*, in so far as it is the faculty of the highest intuitions. It holds all the direct revelations of faith, all positive or *a priori* certainty, all absolute and incontrovertible knowledge. Of absolute knowledge we have examples in pure mathematics, and in every axiom or proposition which carries with itself the perception of its necessary and universal validity. From the decisions of pure reason there can be no appeal. No professed infallibility, of pope or conclave or synod or man or body of men, can shake the assurance with which we accept the decisions of self-evidence. Others may think us in error, either through want of the clear insight which we enjoy, or through misunderstanding some of the details or bearings of our decision. Whatever we know to be true, no one else can know to be false, however much he may doubt it or however absurd he may think it. The Christian philosopher ranks among the most valuable portions of his absolute knowledge the facts of his own religious experience; the certainty of spiritual being; the self-evidence of a SELF-evident source and authority for self-evidence; the necessary Being of a Planner and Lawgiver to prepare the plans and enact the laws of the universe.

Practical Reason is nearly represented by Kant's *Praktische Vernunft*. It works in the field of morality, for the formation of character; furnishing motives for the guidance of the will; fitted, under the divine sanctification of desire, for the inauguration of noble purposes; giving the real knowledge which makes by far the largest portion of our intellectual attainments. Real knowledge embraces every fact which we are compelled to believe by the constitution of our minds, but of which we do not perceive the absolute necessity. Absolute and real knowledge are often so closely united that it is difficult, especially for persons who have not been thoroughly trained in habits of nice discrimination, to tell where the absolute ends and the relative begins. For all practical purposes, the authority of a truth, which is valid under all the relations by which it is surrounded in our apprehension, is just as binding as the authority of a truth which is valid under all possible relations. Moral certainty is as much the gift of God, and therefore as obligatory, as self-evidence. Both physically and spiritually, the absolute knowledge of others may become our real knowledge, provided we are satisfied of their truthfulness. By practical reason we learn that we are surrounded on every side by limitations which we cannot overleap; that we are, to some extent, the creatures of circumstance; but that, within our bounds and under all possible circumstances there are such things as right and wrong, duty and responsibility; that we must, therefore, have so much freedom of choice and action as is necessary for the exercise of our responsibility. God has provided for the satisfaction of our needs by giving us a real knowledge of what will elevate our character, as well as by giving us an absolute knowledge of what will elevate our thoughts.

Logical, or Empirical Reason is the faculty which is commonly regarded as the crowning glory of man, by those who look upon reason and faith as mutually antagonistic. It is, however, rather an evidence of intellectual weakness than of intellectual strength; because its sole office is to unfold what is given us by pure and practical reason, and because it is exposed to all the mistakes which may arise from undue assumption of premises as well as from fallacious inferences. Kant calls it *Urtheilskraft*, the power or faculty of Judgment. It works largely in the field of science, for the classification of phenomena; examining especially the information which comes to us through the avenues of bodily sensation; confining itself, therefore, mainly to the interpretation of the material universe; and attaining, by its unaided efforts, only to problematical knowledge. Problematical knowledge covers everything which we believe to be true, but the truth of which depends on circumstances which it is impossible for us to determine with certainty. The vacillations and inconsistencies of scientific theories and systems are due, at least partly, to the attempts to disregard or discredit the testimony of the only faculties which can give us positive knowledge.

Fortunately for the interests of truth, and fortunately for science itself, such attempts are always vain. Whether we are aware of it or not, the inspirations of understanding compel us to act under the instinctive promptings of our highest faculties. We may scoff at metaphysics if we will; yet, if we study at all, we speedily find ourselves trying to explain and coördinate the physical facts which we accumulate by observation and experiment. The question, *what*, is necessarily followed by the question, *how;* fact points and leads irresistibly to theory and law. For the completion of possible knowledge the question, *how*, is naturally followed by the question, *why;* theory and law indicate such accordances of thought and will, as may be readily understood if we believe that they represent the activity of a Thinker and Willer, and such as cannot be satisfactorily explained on any other hypothesis. In order that any physical phenomena may be brought within the domain of scientific thought, we must have faith in the validity of the simple presentation, enough curious desire to keep up a proper representation, enough understanding to distinguish the general from the special and the essential from the accidental.

Religion, entrenched in the citadel of faith, has always been helped by antagonism, gaining new strength from every new struggle. Skepticism, assuming protean forms and continually shifting its ground, tries in vain to dislodge its antagonist, and at every assault furnishes new weapons to be turned against itself. The old truths, the primitive beliefs of our race, are still as precious as ever; beyond the reach of death and decay, they continue to hold forth the promise of participation in their own eternal youth and vigor, to those who will accept and rightly use them. Such acceptance and use always bring a full assurance of knowledge, which shrinks from no controversy that is worthy of notice. But skepticism is too apt to forget the two fundamental rules of controversy: that for every individual, self-evidence outweighs all other evidence; and that, whenever

self-evidence is not attainable, only qualified judges are competent to decide mooted questions.

Philosophy neither needs nor seeks any suppression of facts, and it is not fettered by any theories, however skilfully they may be framed or however haughtily they may be set forth. It grants to science the right of self-imposed limitation to the field of material phenomena, and it accepts material laws as the true keys to material facts, but it looks to moral and spiritual laws as the only keys to the facts of moral and spiritual life. It does not go to a doctor for legal advice, or to a theologian for scientific instruction; it cares little for a deaf man's judgment of a symphony of Beethoven, or for a scientific theorist's views upon a question of religious experience; but it welcomes from every quarter, from Religion, Ethics and Science alike, any new revelation of the eternal truths of God, and it always strives to reach such clear insight into the harmonies of truth as will help it to dispel the mists of human error. No truth is so insignificant that its place would be better filled by a plausible falsehood; none is so formidable that it can overthrow any other truth. The "may be" of the shrewdest conjecture, the "perhaps" of the wisest hypothesis, may be helpful to the investigator, and the philosopher will always gladly accept every well-established result to which they may lead; but they count for nothing against the "surely" of self-evidence or the "therefore" of experimental knowledge.

"A thoughtful writer," cited by Dr. Pusey in a late Oxford sermon, says: "Special studies, which bring into play any special aptitude of intelligence without paralyzing the rest, are conformable to the wants of nature. Exclusive studies, which amass a sort of conjectural life upon one point of the mind, leaving the rest in inaction, are but abnormally developing the excresences of intellectual life; so when special science forms men who are eminent, exclusive science produces judgments which are false. Exclusive science is the only one injurious to religion, but it is also the only one opposed to it. What withholds man from faith is not the knowledge of nature which any one has, but the knowledge of religion which he has not."

The Christian philosopher would gladly share this knowledge with others, but he can point out no other way for its attainment than that of direct revelation. He is often astonished at the condescension of God; he asks, with David, "what is man, that thou art mindful of him, and the son of man, that thou visitest him?" If any satisfactory answer can be found to the question he believes that it should be sought by looking upwards, and not downwards; by following the leadings of the highest spiritual truths, and not by sounding the quagmires of material truth; by studying the records of Supreme Power and Wisdom, not by stopping short at the laws of protoplasm and chemical affinity and molecular motion.

The materialist boasts of the positive knowledge which can be attained by the senses, and regards nothing as worthy of investigation which cannot be verified by sensorial observation and experiment. The Christian

recognizes the value of the sensorium as an instrument of mind, and the reverence with which he regards his experimental religious knowledge, leads him to appreciate, at its fullest worth, experimental secular knowledge. But the worth is spiritual, not material. Beauty and order and law are spiritual attributes. The microcosm of each individual is what his spiritual discernment sees it to be, even as the macrocosm of the universe is what God saw it to be, when "he spake, and it was done; he commanded, and it stood fast," and when he "saw everything that he had made, and behold it was very good."

The deceptions of sense are proverbial. We learn, by experience, to correct such as are practically harmful, but the correction involves an exercise of judgment, an assertion of the controlling authority to which sense always is, as it was intended to be, subservient. If each of our senses may sometimes deceive us we can get no valid authority from any combination or comparison of mere sensorial findings. But if the spiritual interpretation of every finding has always a relative truth, a way is opened for supersensual knowledge. The unsoundness of any claim that such interpretations are "the evidence of the senses" may be made more glaring, by showing that sense-deception is not exceptional and rare, but normal and universal.

Take the sense of sight. The most advanced physical science of our day teaches that light and shade, color and visible form, are due solely to wave-motions in the luminiferous æther. These motions are received by an optical instrument, consisting of a combination of lenses and transparent media of various refracting powers. Whatever doubts any one may have as to the Contriver of this wonderful instrument, there can be no doubt that it was made with a specific design for a specific end or purpose; that it was designed to meet certain wants or needs of its possessor, and that its purpose is vision. There is little room for doubt that the æthereal vibrations enter the eye, and are transmitted to the brain, where Consciousness receives them, not as wave-motions, but as a beautiful and inexplicable panorama of blended ideal harmonies and contrasts. Light as we know it, and light as a material agency, are two entirely distinct realities. The spiritual power of the soul transforms the simple motions into conceptions, supplementing creative purpose by introducing a new order of things, and showing that the highest reality requires, for its continued existence, the continual exercise of intelligence.

Turn next to hearing. The unanimous verdict of the most competent judges is again in favor of motion, as the physical instrumentality of all the impressions which reach us through this important sense. The waves, however, are now in a much grosser medium, and are received by a much more sluggish apparatus. While the slowest visible light waves vibrate more than three hundred million million times in a second, the swiftest audible sound waves do not vibrate more than seventy-five thousand times in a second. The frequency of vibration is, therefore, more than four thousand million times as great in light as in sound. The atmospheric

waves strike the drum of the ear, awakening answering vibrations in the organs of the inner ear, where they are received by the delicate branching fibres of the auditory nerve and sent to the brain. There Consciousness receives them, not as waves. nor as motions of any kind, nor even as light, but as transformed, by the soul's spiritual activity, into a new order of spiritual conceptions; conceptions which have a reality of the highest degree, but a reality which exists only so long as it is upheld by the power of intelligence.

Taste and smell are more nearly alike than any other two senses, and they may be examined together. The influence of wave motion is not so evident in them as in sight and hearing, but there is no reason for doubting that the gustatory and auditory and all other nerves transmit their impressions to the brain and receive their influences from the brain, by waves or beats. Tyndall's investigations show a striking resemblance between odors and vapors in their absorption and radiation of heat; sapid substances are always soluble, and taste is not excited until some solution is made. Both these senses, therefore, require a preliminary breaking up of cohesion, and consequent increase of active elasticity. The "kinetic theory of gases," which was first proposed by Daniel Bernouilli, supposes that they are formed of material particles, animated by very rapid movements, and that the tension of elastic fluids results from the shock of their particles against the sides of the vessels which enclose them. In discussing the theory most physicists, and perhaps all, have assumed the motions of the particles to be rectilinear, but cosmical analogies indicate a probability that they may be more often elliptical, and perhaps often parabolic or hyperbolic. The likelihood of continual internal motion, of some kind or other, amounts to moral or practical certainty; the probability that taste and smell are in the same category as sight and hearing, objectively as well as subjectively, is, therefore, incalculably great, and if some skilful physiologist should announce the discovery and measurement of waves of smell and taste, the discovery would awaken great interest but little or no surprise. While awaiting the discovery we know that the throbs of the different nerves, which terminate in the mouth and nose, finally reach the brain, where Consciousness receives them, not as waves, nor as motions of any kind, nor even as light nor as sound, but as taste and smell. The spiritual wonder-worker again uses its transforming power to set forth new orders of conceptions; conceptions full of living reality, but a reality which requires the action of intelligence, both to call it into being and to maintain its existence.

The sense of touch seems so completely to underlie all the others, that they are often spoken of as modifications of touch. There are, however, some special considerations, connected with the general sensitiveness of the skin, which are worthy of notice. Many of the most important bodily sensations, at least in a physiological point of view, are dependant on temperature. One of the most interesting modern physical treatises is Tyndall's "Heat as a mode of motion." In that work, the successor of Fara-

day recounts the experiments of an American-born citizen, Benjamin Thompson, commonly known as Count Rumford, together with subsequent confirmatory experiments of remarkable nicety and remarkable fruitfulness, by Joule, Mayer, Colding, and others. Those experiments all point to molecular motion as the source of heat, and their recognized importance is so great that the new science of heat, or "thermodynamics," ranks as one of the chief physical sciences. Some even go so far as to think it the only physical science, or at least the fundamental science. The genial glow of the hearth-fire may quicken the circulation; the quickened circulation may enliven the spirit; but the spiritual enlivenment and the pleasant sensation of warmth by which it is accompanied are both very different from motion, and from all other sensations. They are both realities of a higher order than any mere physical fact; realities that are only possible in and through intelligence.

The other tactile sensations as well as the renderings of the muscular sense may be referred to various degrees of resistance, dependent upon the aeriform, liquid or solid condition of the body which awakens the sensation. We have already seen that elasticity may be explained by motion, and even the most solid bodies are often highly elastic. The advocates of the atomic hypothesis commonly regard the ultimate atoms as very hard, but the mathematical requirements of the relation between heat under constant pressure and under constant volume point to great elasticity. The new chemistry, and Lockyer's late spectroscopic discoveries, also have the same ultimate pointing. They regard all the chemical elements as based on the hydrogen atom, and it has been shown* that the elasticity of hydrogen is so simply related to the elasticity of the luminiferous æther that hydrogen may be merely condensed æther. All the particles of steel and platinum and of all other material substances are supposed to be in endless motion, through orbits of minute extent which are traversed in brief periods with great velocity. The resistance of such orbits to any change of relative position increases in proportion to the square of the velocity, so that any desired degree of rigidity might be obtained, without any actual contact of particles, by simply giving them velocity enough. The nervous action which is excited by the resistances of physical impenetrability, is transmitted to the brain, where it is received by consciousness, not as motion; not even as light, nor as sound, nor as taste, nor as smell, nor as warmth, but simply as resistance; a spiritual reality of a higher order than anything which is merely material; a reality which is made by intelligence and which is lost as soon as intelligence ceases to wield its upholding power.

We thus see that the "evidence of the senses," so far from being a correct transcript of outward realities, is always as deceptive as the seeming quiet of the seeming general flat terrestrial plane, and as the seeming daily revolution of the sun and moon and stars around our seeming centre of the universe. Our natural and irresistible conviction, that the senses report

*Proc. Am. Phil. Soc., xii, 394; xiii, 142.

things as they are, experiences a shock when we find that there is no more resemblance between the material type and the spiritual reality, than there is between the letters of the alphabet and the ideas which they serve to convey from one intelligence to another. We then begin to see the importance of distinguishing the secondary or delegated cause, both from its immediate consequence and from the Great First Cause; we understand the shrewdness which led the scholastic wranglers to say that there is no light in the sun, no sound in a bell, no sweetness in sugar, no fragrance in a rose, no heat in fire, no cold in ice, no hardness in a diamond; the fundamental doctrine of Berkeley, as expounded by Kant, that "all phenomena are merely subjective representations in consciousness," becomes very suggestive; we learn that the universe, as we know it, could only have been made by intelligence, and that it can only be upheld by intelligence; we know that our consciousness, limited in all directions as it is, has, nevertheless, enough delegated power and authority to enable it to make, uphold, direct and govern all the subjective realities which are essential to its own welfare; we know, also, that such delegated power and authority could only have been delegated by a still higher subjective Spiritual Being.

Must we then reject all belief in objective reality? By no means. Even the apparent immobility and disk-like shape of the earth, as well as the constant daily and yearly apparent motions of the heavenly bodies, have a practical and relative truth which we are compelled to act upon and which is always helpful. We can never attain to absolute knowledge of anything which we have not made our own by subjective experience, but we have a real or practical knowledge of everything that awakens an instinctive belief in its reality. Some men will doubtless continue to argue for ages to come, as others have argued for ages past, on the one hand against the possibility of motion, on the other against the possibility of free agency. But the former will show their practical disbelief in their own theories by their own bodily changes of place; the latter, by their continual exercise of free-agency, their satisfaction when they have done right, and their remorse when they have done wrong. There is nothing so self-evident that men may not try either to refute it or to make it plainer, and mystify themselves by so doing. Arguments have been framed to prove that black is white, that one equals two, that Achilles could not overtake a tortoise, and the fallacies have been so artfully covered that many persons have tried in vain to detect them; nevertheless they have not been beguiled into accepting any of the specious sophisms, although they may have had their faith shaken in the infallibility of the reasoning faculties.

The proper co-operation of all our faculties will always lead us to such truth as God intended we should reach by their help. The difference between the lower, obscure, problematical or practical truth, and the higher, self-evident, subjective or absolute truth, is an indication of educational purpose. If we are satisfied to rest in the lower, we have no right to complain that the higher is hidden from us; if we shut our eyes to the self-evidence that is offered us in one direction, we have no right to ask for

proof in another, proof which would be necessarily sophistical if it could be plausibly framed. The man who is either blind or color blind, or who has any other bodily defect, has an imperfect instrument for the use of his spiritual ability, and the imperfection will affect all his work; but it will not prevent his reaching the absolute and the relative knowledge which are best for him, provided he employs his ability to the best advantage. If his limitations unfit him for the reception of any truths but those of physical or natural science, let him devote himself to the labor for which he is best fitted; but let him not scoff at other truths, and above all, let him not waste time and strength in seeking to solve, by scientific or "positive" methods, problems which can be solved only by metaphysical or by theological methods. Philosophy and religion offer to science the help which is needed in order to make knowledge complete and symmetrical. If the help is rejected, every attempt to supply its place, by means which God has not sanctioned, will surely fail.

Berkeley's teachings have greatly modified modern materialistic theories. The old idea of inertia, as the essential property of matter, and as implying complete passivity under the controlling influence of immaterial force, is nearly obsolete. Not only is force continually spoken of as material, but will is at the same time spoken of as the "highest form of force." Every writer may be allowed to define the terms which he uses, in his own way, and a complete system of science may be, undoubtedly, built upon a definition of matter as "a substance which may be either conscious or unconscious, either living or dead, either active or incapable of action, either directing or directed, either originating or originated." But there is always danger that a generalization, which embraces opposite qualities in a single conception, may lead to inadvertent reasoning in a circle and to the begging of important questions. It is well that the controlling supremacy of intelligence, upon which Berkeley insisted so strongly, should become more generally recognized, but it is not well that any needless risk should be run of assuming, in defiance of all positive proof, that anything which has once been subordinate can ever develop itself into supremacy over what has once been supreme. Even if we enlarge our ideas of matter so as to embrace all possible forms of being, we do not remove a single difficulty thereby. The same questions come crowding up before us, only under different forms. Instead of asking, "what are spirit, and soul, and mind, and will, and force," we ask, "what are consciousness, and life, and action, and government, and origination." In spite of all our attempts to reconcile the unreconcilable, the eternal facts remain, that there are spiritual phenomena in the field of consciousness and time, and physical phenomena in the field of inertia and space; that all attempts to subordinate the former to the latter have always failed, and that the physical exists only to serve the wants and purposes of the spiritual.

It is not strange that mechanical philosophers should sometimes think that all consciousness is connected with a brain, for the highest organic mechanism that is directly and sensibly tributary to consciouness is un-

doubtedly to be found in the human brain. But the Christian sees evidences of the sway of consciousness everywhere; in the rudimentary nervous systems of insects and molluscs; in the busy industry of coral-building polyps; in the shapeless jelly of the amœba; in the development, from a single cell, of the most complicated vegetable and animal forms; in the structure of crystals; in the formation of compounds, with new properties, by chemical affinity; in the continual renewals of creation during each returning year; in the unity of plan which is manifested in the arrangement of planets and of spectral lines; in the modifications of that plan which are displayed in vegetable growth and in stellar systems; in all the indications of life, and law, and order, and purpose, and adaptation of means to ends with which the universe is filled. If steam engines could think, they might regard steam as the source of all the varied and intricate designs which are wrought out by machinery, with much more reason than man can give for regarding the brain as the source of consciousness.

The more mechanical consciousness becomes, either in its immediate or in its mediate manifestations, the less is the liability to mistake. The instinct of animals is more unerring than the reason of man; crystallization and organic growth follow established design more closely than instinct; the cell, which was meant for one part of the body, rarely goes to any other part; machinery accomplishes its results with greater uniformity than manual labor; the calculating machine computes difficult tables with more certainty than the most skillful mathematician. Mechanical philosophy may naturally regard mechanical perfection as the best evidence of superiority, but a higher philosophy esteems freedom more highly than automatism, and consequently finds in the possibility of imperfection, evidence of a high degree of perfection. Man, sinful as he is, and "born unto trouble as the sparks fly upward," is a nobler creature, from the very fact that he has the power to choose between right and wrong, than he would be if he were compelled always to act from unerring instincts. Now, he is capable of indefinite progress; then, he would have been stationary; now, virtue and merit and satisfaction in the performance of duty are within his reach; then, he would have been a mere slave; now, he has a distinct personality, created in the image of God, made a little lower than the angels; then he would have been a mere machine.

Liebnitz and Coleridge and Cousin all gave great prominence to the doctrine that "Systems are true by what they affirm, but false by what they deny." "The heavens declare the glory of God;" but "the fool hath said in his heart, there is no God." We may affirm that consciousness is connected with a brain, but if we say that all consciousness is connected with a brain, we deny the positive assertions of others and make a gratuitous assumption which is scientifically untenable. We may admit, with Hæckel, that every organic cell has a conscious "soul life;" that in the infusoria a single cell performs all the different functions of life; that, *perhaps*, in the higher organisms, the numerous single cells give up their individual independence, and subordinate themselves to the "state-soul" or

"personal soul," which represents the unity of will and sensation in the "cell-association;" and that his theory brings all natural phenomena into a mechanical causal connection, as parts of a great and uniform process of development. But if we deny that there is any higher soul or life or power or wisdom than is manifested in single organic cells or groups of cells, or if we deny that every "mechanical causal connection" must have a mechanic to make the causal connection, or if we deny any other theory which is more satisfactory to its upholders than our own, we overstep all scientific bounds and our words are as worthless as the babble of a child. We may accept the alternative, "natural development or supernatural creation of species," and we may explain the two hypotheses in such way as to present no necessary antagonism; but if we deny the necessity of an intelligent author for every established order and an intelligent originator for every consistent plan, we only show our own foolishness. We may believe, with Cousin, in an impersonal reason which pervades the universe like a spiritual sea or atmosphere, which is the mediate source and endless supply of all finite knowledge and all material development; but if we deny the existence of a personal reason which is still higher, our vanity leads us into arrogant blasphemy. If we open our intellectual eyes to the light of the highest philosophy, we may see that the truths of affirmation, in all philosophical systems, are partial recognitions of this higher truth which includes them all: wisdom "was set up from everlasting, from the beginning, or ever the earth was."

Modern science is too prudent to make such denials, and none of them have ever been made by men whose opinion is worthy of the slightest consideration. The methods of observation and experiment only lead to the discovery of what is; they furnish no grounds for positive assertion of any kind, beyond a simple statement of facts. But the natural disposition to theorize, which is praiseworthy when it is employed merely as a help to investigation, often leads men to attach too much importance to ingenious hypotheses, and to suppose that the explanation which they accept is the only reasonable one. Moreover, the commendable caution, which leads honest and ready investigators to publish nothing that has not been thoroughly tested by their special methods, is apt to be misunderstood. If men, whose talents, education and calling give them a peculiar aptitude for research, hesitate to affirm a mooted doctrine, their admirers often take the hesitation for a denial. The supposed denial has, for them, both the fascination of novelty and the witchery of authority; they therefore adopt it eagerly, priding themselves on their independence of thought and their superiority over the prejudices of education and tradition.

It therefore behooves every one, whose views are likely to influence others, to be very watchful lest he become instrumental in breaking down any of the barriers against immorality. If his assurance of important spiritual truths is not sufficient for him to speak with positive certainty, he should at least guard against such misinterpretations of his teachings as he is unwilling to accept, and he should claim the same rights and the same

authority for students in other fields as he claims for himself. Let his scientific reputation be as high, and his physical discoveries as brilliant as they may, he may feel himself honored by the avowal that he is a lover of wisdom, like David and Solomon and John and Paul, and by owning that their experimental knowledge of the spiritual truths, which they proclaimed, was as positive as his own experimental knowledge of the physical truths which he proclaims. He cannot show that physical truth is more important than spiritual truth, nor that the scientific writers of our day are more honest, more capable, more careful, or more thorough than the religious writers of the early Christian days. Let him not claim, then, even by the faintest shadow of implication, that the prophets and evangelists and apostles were less competent judges in their special field of experience, than he is in his, or that their assertions are less trustworthy than his own.

Büchner offers the following dilemma: "Either the laws of nature rule, or the eternal reason rules; the two would be involved in conflict every moment; the sway of the unchangeable laws of nature, a sway which we cannot call a rule, would allow of no conflicting personal interference."* The dilemma itself is well stated, but it is difficult to see how any one who believes in "eternal reason" can accept his solution. How can laws, having "a sway which we cannot call a rule," rule anything? What are "laws" and "eternal reason?" Before we attempt to dogmatize, we should try to express our meaning so plainly that it cannot be easily misunderstood. To the Christian philosopher, the assertions that "the two would be involved in conflict every moment," that the laws of nature are unchangeable, and that their sway "would allow of no conflicting personal interference," seem like mere gratuitous assumptions.

The primitive meaning of law, as defined by Webster, is: "A rule, *particularly* an established or permanent rule, prescribed by the supreme power of a state to its subjects, for regulating their actions." Between the laws of man and the highest human reason there is rarely any conflict. No human laws are unchangeable, but the more reasonable they are the less likely are they to be changed. If they were in accordance with eternal reason what ground can any one have for thinking that "the two would be involved in conflict every moment?"

The primitive and etymological meaning of nature, is "that which is born or produced." By metonymy nature is taken to represent the producer, and Darwin defends this use of the word in language which seems to imply his undoubting belief that the producer is intelligent. Büchner says: "Nature is a single totality sustained by an internal necessity."† This definition might be interpreted to include "the eternal reason" as a part of nature, but it seems likely from the terms of his dilemma, that he agrees with most other German philosophers, in contrasting nature, as the material world, with the world of intelligence. If such is his meaning, and

*Cited by Krauth.

†Ibid.

if he intends to assert that the material universe is sustained by an internal necessity which is independent of any supernatural influences, he is simply begging the question.

What are called "the laws of nature" are merely the generalizations of our own minds. They represent facts, of order, and harmony, and mutual relationship, which have been observed so often that we look upon them as invariable, and nearly every provision which we make for future contingencies is grounded upon our confident belief in such invariability. If we were to ask how a religious or political organization is governed, we should think it a very unsatisfactory answer to be told that "the laws of the organization rule." It is equally unsatisfactory to be told that the laws of nature rule, when we ask, what governs nature? We are not children, to be stopped in our questionings by a simple "because," or to be contented with the assurance that certain orders of fact occur because those orders of fact always occur. Yet what more do they offer us who talk of "the sway of the unchangeable laws of nature?" Who will say that protoplasm or chemical affinity rules the conscious movements of the infusoria, or the amœba, or the higher organizations which use nerves and ganglia as the instruments of consciousness.

However we may try to account for the origin of consciousness, we cannot divest ourselves of the belief that consciousness is the ruling power of its own polity. Even if we can bring ourselves to think that the "cell-soul" is the product of the material forces which organized the cell, we cannot help thinking that, after it is "developed," it rules the cell; even if we define matter so as to include all phenomena, the only ruling force that is self-evident is the force of will. Seeing an established or permanent rule in the material universe, which resembles the "established or permanent rule prescribed by the supreme power of a state to its subjects," we reason from analogy and call the natural rule, as well as the human rule, a law. Extending the analogy, we look upon the "laws of nature" as rules prescribed by the supreme power of nature. The Christian philosopher extends the analogy still further, and finds that all his questionings are satisfactorily answered by a simple acceptance of the revelation, that the supreme power is an Omnipresent, Almighty, "Eternal Reason," and Will, and Love. According to the only intelligible conception which he is able to frame, of the laws of nature and the eternal reason, we have no grounds for saying that "the two would be involved in conflict every moment." On the contrary, any conflict is an absolute impossibility. "The sway of the unchangeable laws of nature, a sway which we cannot call a rule," continues only so long as God wills; the laws are unchangeable only while their Author does not wish to change them; there can be no such thing as "conflicting personal interference," because at the moment when there would be an interference, provided the laws had an independent existence, the change in the Divine Will makes a corresponding change in the laws.

In this conception all the terms are used in their simplest, most obvious, and most general acceptation. If the teachers of a different doctrine have

a well defined notion of the laws of nature, which enables them to give up the idea of an intelligent Ruler, it would be much better that they should express the notion by some other term than law, and they should by all means give such clear definitions as will enlighten the understanding of their readers. If they have no such notion, they use "words without knowledge." The use may be honest, and free from intention to deceive, for every one is liable to an inconsiderate employment of terms which have been familiar from childhood. But a professed searcher for truth, who believes that the majority of thinking men have, for ages, been blinded by error, can hardly be excused for forcing their expressions into a meaning which they would unanimously repudiate. Such a course may lead to one of those endless wars of words which constitute a large portion of the fancied oppositions between science and religion, but they hinder, instead of helping, the spread of knowledge. When science claims the right of free discussion, the right must be granted, but only in legitimate ways. The etymological bond between *reor* and *res*, *reason* and *real*, *think* and *thing*, is only one out of many indications that philosophy is only concerned and can only deal with ideas; that the ideal is, as Plato taught, the only reality to which we can possibly attain; that all manifestation, material as well as spiritual, is only the expression of ideas; and that nothing can be gained by trying to banish or ignore the highest ideas which have been revealed to men and to shut them within the narrow bounds of manifestation, of which we can know nothing except through subordinate ideas.

The highest philosophy, while it seeks for nothing but the truth, will be satisfied with nothing short of the whole truth; truth to the whole triplicity of human nature; truth which can harmoniously promote all the purposes of revelation, sanctification and inspiration.

A strong feeling of spiritual need, with the implicit dependence upon the intimations of faith which is its natural accompaniment, gives philosophy a leaning towards mysticism; the happiness, which accompanies every satisfaction of the need, awakening a thankfulness to the Giver of all good and a recognition of His benevolence which lead to theories of *optimism*. An energetic, self-asserting will, with an accompanying disposition to yield to every impulse of desire, gives a tendency towards dogmatism; the abuses of freedom, which characterize "the natural man," giving belief a subjective bias which is shown in systems of *pessimism*. Active reasoning powers, leading to a continual exercise of thought upon speculative questions, give rise to skepticism; the impossibility of reaching any conclusion, in which something is not taken for granted, convicting finite reason of inherent weakness, throwing a shade of doubt over every commonly accepted belief, and tending towards *nihilism*, or a denial of all reality. Christianity assigns each group of theories its proper limits, by teaching that "God is good;" the human "heart is deceitful above all things, and desperately wicked;" "the natural man receiveth not the things of the Spirit of God, for they are foolishness unto him; neither can he know them, because they are spiritually discerned." There is no inconsistency in believing: 1, that

the created universe is the best possible, when considered with due regard to all the purposes of creation ; 2, that our world is the worst possible, in view of the evil which has resulted from the intentional interference of human liberty ; 3, that no certainty can be reached by a reason which starts with the assumption of its own independence, and refuses the guidance which is offered by its Creator.

Aristotle says, "philosophy began in wonder."* Wonder leads naturally to admiration, admiration to investigation. Through wonder we learn, and the facts which we thus acquire constitute the largest, as well as the most important portion of our knowledge. Through admiration we become attentive, attention giving distinctness and thoroughness to knowledge. Through investigation we unfold the truths which we have already ascertained, and although we are not directly led to new truths, we discover new relations, which may excite new wonder and admiration, thus leading indirectly to the knowledge of new facts. Wonder, admiration and investigation all aim at the highest conceivable ends. Each of them finds special ends of its own, which are so important that they are sometimes looked upon as all-embracing. But the partial can never be so comprehensive as the general ; the satisfaction of one want is inferior to the satisfaction of all. The fondness for study and investigation is implanted in us for the formation of character, and no better test can be given, of the importance of any belief or pursuit, than the influence which it is likely to exert, either in elevating or in degrading the soul. The order in which the fundamental questions of philosophy naturally arise, tends to lead the mind from effect to cause, and from cause to final cause or purpose ; from creation to creative power, from creative power to creative design ; from manifestation, and power, and purpose to the Source of all things, the only true God, who is at once Upholder, Creator and Designer. Physical science very properly recognizes the fact that the investigation of final causes and of other metaphysical problems is out of its province, but for that very reason it should not reject the help which theology and philosophy are always ready to give it.

There is no field of natural science which is not full of pointings, backward to the unconscious, and forward to the conscious. Matter is manifested in various forms which are known as chemical elements ; elements combine to make compounds of various properties ; both elements and compounds often occur in crystaline forms, each crystal being built upon a definite plan ; through the mystery of life inorganic matter becomes organic, the simplest manifestations of organizing force transforming the mineral into the vegetable, and higher manifestations making vegetable life tributary to animal life ; both in the vegetable kingdom and in the animal kingdom there are many gradations, from lower to higher species and genera and orders and classes ; the visible creation culminates in man, who boasts his pre-eminence mainly on the ground of his superiority in intelligence.

Throughout this ascending scale of being, in which, at every step there

*Cited by Krauth.

is something added to the step below, there are unmistakable evidences of a unity of design, such as would result from a unity of Supreme Intelligence. The likeness of finite intelligence to Infinite Intelligence, is shown both by the power of partially comprehending the designs of the Creator and by the power of scientific anticipation, which sometimes leads to important scientific discoveries.

Evolution, development, execution of purpose, are facts of every day experience. Religion, Morality and Science are all called to deal with them, each according to its own methods. Science, of its own choice, has taken the mechanical method, which is the lowest of all, although it may be as important as any, provided it is employed in the proper spirit. All the details of evolution and development, which can be discovered by the most untiring search, are portions of God's truth, and we owe many thanks to the earnest, hard-working men through whose diligence they are made known to us. But evolution as a fact or law expressing a Divine method, is one thing; evolution as a self-sufficient theory, is quite another thing. The fact must be accepted, just so far as it is shown to be a fact, and no further; the theory is only a child's answer to questions of the highest import.

The engineer, deeply interested in the workings of an intricate machine, may study it in all its parts, watching the bearing of every joint, and lever, and cog, and band upon the result which the whole combination was intended to bring about, and admiring the simplicity of contrivance which, by avoiding all superfluity, displays the inventor's wondrous skill. His own knowledge may be enlarged by the study, and he may find himself greatly helped by it in subsequent important professional undertakings. But what should we think of his scientific wisdom, if he should try to enlighten us in regard to the orgin of the machine, by telling us that the atom-souls give up their individual independence and subordinate themselves to the molecular-souls; that the molecular-souls, in their turn, subordinate themselves to the joint- and lever- and cog- and band-souls; that the joint- and lever- and cog- and band-souls subordinate themselves to the machine-soul; that all the lower forms of consciousness thus become tributary to the higher consciousness of the machine's state-soul or personal soul, which represents the unity of will and purpose in the atom-association; and that thus all the phenomena of the machine are brought into a mechanical causal connection as parts of a great and uniform process of development? If we study the mechanism of the eye and ear, and the contrivance by which they are fitted for their intended purposes, can we show any greater wisdom by suggesting a similar explanation as final and sufficient? Religion, Morality and Science may all be satisfied by accepting the teaching of David and Solomon, and in no other way: "He that planted the ear, shall he not hear? He that formed the eye, shall he not see?" "The hearing ear, and the seeing eye, the Lord hath made even both of them."

There can be no question that a too great and exclusive absorption in the study of outward nature, will lead us towards materialism, and that materialism will tend to dwarf our spiritual growth. There is little risk,

while physical research continues so rife as it now is, of our becoming too spiritual; consequently there is little risk in the spread of spiritual instruction, as an antidote to the philosophy which ignores all spiritual control. These grand maxims should be indelibly impressed on every mind, and above all on the minds of physical investigators; that "we have a higher warrant for believing in God than for believing in any other truth whatever;"* that the simplest exercise of thought proves the existence of spirit, while the existence of matter "as a distinct entity has never been proved, and is seriously questioned;"† and that, even after we have granted the reality of an inert, unknowing somewhat, which underlies material phenomena, we should still look to the wisdom which sways, as higher than the ignorance which is swayed.

Our age is often called an age of materialism, but when we compare it with previous ages we may find much to be said in its favor, while the faults, with which it is justly chargeable, lie partly at the doors of Christian believers who have neglected their religious duties. Most investigators, in every age, limit their researches to fields in which there is the greatest likelihood of discovery, and in which general interest may be most readily awakened by direct appeals to the senses. This is in accordance with evident Creative Design, for the senses are the only known avenues of intercourse between the spirit of man and the material universe, and the beginnings of education come through such intercourse. The great end of education is, however, spiritual, and if our spiritual teachers do not keep pace with the age, we must all suffer loss. We need, therefore, educated guides, as well as educated followers; a body of apostles, prophets, evangelists, pastors and teachers,‡ capable of understanding and rightly qualified for interpreting and reconciling, the truths which skillful decipherers have drawn from the Bible of creation, as well as those kindred truths of kindred revelation in the Bible of Scripture, and in the Bible of the soul.

Although timidity has hitherto greatly blocked the way against such interpretation, we have reason for congratulation in the unconscious shaping of physical theories by spiritual intuitions. Newton, near the close of his Principia, says: "This most beautiful system of the sun, planets, and comets, could only proceed from the counsel and dominion of an intelligent and powerful Being;" and in his third letter to Bentley: "It is inconceivable that inanimate brute matter, should, without the mediation of something else which is not material, operate upon and affect other matter without mutual contact;" La Place supposed the velocity of gravitating action to be instantaneous, a velocity which is impossible save through a spiritual medium; Tyndall, in speaking of the "potency" of matter, expressly admits that he does not seek to degrade spirit, but to elevate matter, and in his Manchester lecture he indignantly disclaims "that creed of atheism which has been so lightly attributed to him;" Huxley avows himself a spiritualist, rather than a materialist; Maudesley regards will, as the highest

* Ex-President Thomas Hill.
† Rowland G. Hazzard.
‡ Eph. iv, 11.

form of force; Maxwell says that the progress of science has "tended to deepen the distinction between the visible part, which perishes before our eyes, and that which we are ourselves, and to show that this personality, with respect to its nature as well as to its destiny, lies quite beyond the range of science;" Barker, in his address before the chemical section of the American Association, quotes the definition of matter, as "that which is essential to the existence of the known forms of energy, without which, therefore, there could be no transformations of energy;"* Cope, in discussing the origin of the will, speaks of "the goodness of God as the anchor of the universe;" Draper, addressing the Chemical Society, says: "Shall a man, who stands forth to vindicate the majesty of such laws, be blamable in your sight? Rather shall you not, with him, be overwhelmed with a conception so stupendous? And yet let us not forget that these eternal laws of nature, are only the passing thoughts of God;"† Frothingham, in the very extremity of his radicalism, makes the following acknowledgments: "Still, that whatever power there is, is alive, in every atom of space, in every instant of time, is put beyond controversy, and manifest, let us add, in a much higher form in mind than in visible matter." "It is impossible for me not to believe that the universe is governed by an intelligent will."

Berkeley himself could hardly have found fault with any of these statements; he would have felt little fear of any materialism which defines matter in terms that would be equally applicable to spirit. Quotations might be indefinitely multiplied, to show that the best devotees of modern science, while they fearlessly assert their right to vindicate the truth of their own discoveries and to accept every inference which may be legitimately drawn from them, admit, in their best moments, that there is a realm beyond the reach of their physical analyses and experiments. In that realm it is the right of religion and morality to work, and by faithful work they may check all tendencies of science which are one-sided or otherwise dangerous. Whoever has a knowledge of spiritual truth, which is as sure as that of John and Paul, may look for a success akin to theirs; whoever presents the results of his religious experience, as clearly and forcibly as Tyndall and Darwin and Huxley present the results of their physical experience, will find that faith and reason, going hand in hand, become mutual helpmeets.

Christian philosophy says to its upholders: Yours might have been, much more largely than it is, the credit of that growing recognition of spiritual power which makes the defenders of truth so hopeful; it is not yet too late for you to resume the armor of your early leaders and renew their career of conquest. Be not afraid to acknowledge the ignorance which you cannot conceal, be bold in asserting the truth of what you know, and science, forgetful of her apparent hostility, will gladly shake hands with you, sitting at your feet as an eager learner of truths which round and supplement her own discoveries.

* Stewart and Tait.

† "The laws of nature are the thoughts of God."—Oersted.

The most thorough-going evolutionists are the fullest believers in the modifying influences of struggle, want, annoyance; all of which are evidences, more or less striking, of an indwelling consciousness which promotes development. The amount of variation which man has assisted in producing, in pigeons, cattle, and other domesticated animals, is often quoted in order to show that neither specific nor generic differences are sufficient to need any unwonted intervention of creative power for their production. In geology and astronomy there are like tendencies to avoid cataclysmic hypotheses, and to seek an explanation of past changes in the earth and in the heavens through such mediate causes as are still at work. These tendencies are not objectionable unless they lead us to forget that the creation of a new cell calls for an exercise of supernatural power as truly as the creation of a universe; that the miracle of every moment is as wonderful as the miracle of developing order out of chaos; that the Upholder of all things is also the Maker of all things; that any relaxation of his mighty energy would be followed by instant and universal confusion. If we keep all these things in mind, our sense of the continual presence of God will lend a solemnity to all our undertakings which will incline us to trust in him as our all-sufficient help and shield.

"In discussing the material combinations which result in the formation of the body and the brain of man, it is impossible to avoid taking side-glances at the phenomena of consciousness and thought. . . . Though the progress and development of science may seem to be unlimited, there is a region beyond her reach, a line with which she does not even tend to osculate. Given the masses and distances of the planets, we can infer the perturbations consequent on their mutual attractions. Given the nature of a disturbance in water, air, or æther, we can infer from the properties of the medium how its particles will be affected. In all this we deal with physical laws, and the mind runs freely along the line which connects the phenomena from beginning to end. But whenever we endeavor to pass, by a similar process, from the region of physics to that of thought, we meet a problem not only beyond our present powers, but transcending any conceivable expansion of the powers we now possess. We may think over the subject again and again, but it eludes all intellectual presentation. The origin of the material universe is equally inscrutable."*

Thus physical research, which starts from faith, and proceeds by faith, ends by sending us back to faith; "the substance of things hoped for, the evidence of things not seen;" for the answer to all our inquiries about the highest realities. Our confidence in the results which have been reached through faith in the phenomena of the lower field, should give us still greater confidence in the phenomena of the higher. The evidence of abundant provision for all the wants of our material nature furnishes a well-grounded assurance that an equally satisfactory provision has been made for all the wants of our spiritual nature.

No doctrine can ever gain extended acceptance, unless it is based upon

* Tyndall, "Heat as a Mode of Motion 4th ed., § 723."

some evident phase of truth. However desirable general knowledge may be, it is attainable only through the accumulation, repetition, and complete mastery of specific facts, by means of definite practical lessons. This is especially true in the case of religion. Drop everything that is or has been denominational, and you will have little left save a vague philosophical abstraction, in which most men may agree, but in which few can find any satisfaction. The "absolute" of the metaphysician; the "supreme" of the scientist; the "all" of the pantheist; represent conceptions towards which the mind is irresistibly driven, but at which all meaning is lost. That which is void of relation, cannot be made the object of thought by beings who think only under relations.

As soon as we admit relativity and attribution, we see that God would cease to be Almighty if He had not the power to reveal himself, in relations of love and sympathy and help, to his intelligent creatures in whom he has himself implanted a wish for love and sympathy and help. Hence arises the metaphysical conception of an "absolute-relative," which accords with the Biblical revelation of an All-wise, Almighty and Ever-living God, who is "not a God afar off," but always and every where near at hand. Under a vague perception of the manifold ties which may subsist between man and his Maker, systems of polytheism arise, of which the most philosophical forms are found in the trinities of the Hindoos and Egyptians. The hidden truth, which they represent, rests upon the mathematical necessity that a relative spiritual nature, like that of man, must be triform; either affected, self-influencing, or affecting; either emotional, voluntary or intellectual.

The revealed doctrine, "God said, Let us make man in our own image, after our likeness," is thus in perfect harmony with the highest philosophical inference of natural religion, and with the "catholic faith" of the Athanasian creed, which worships "one God in Trinity and trinity in unity, neither confounding the persons nor dividing the substance." The conception of the dogma, in the old mythologies, was dim, ill-defined, and generally tritheistic; its deep spiritual meaning was set forth in the Jehovah, Adon, and Ruach, of the Hebrews, the Father, Son, and Holy Ghost, of the Christians.

Religion, as well as science, should always be practical, progressive and aggressive in the adaptation of its unchanging principles to the changing requirements of human progress. Truth is so impregnable that it should court criticism, rather than shun it; our interpretations of truth may be vacillating, but if they are, we cannot give them stability by refusing to examine them. Religion has nothing to fear, save from its own fearfulness; nothing to hope, save in such hopefulness as springs from its own everlasting ground work of truth. Science, resting on reason, asserts its claims with a boldness which almost disarms opposition and carries nearly everything before it; Religion, resting on faith, timidly clings to its traditions, but shrinks from the inevitable contest which is to give them new life.

Our children, with all the natural curiosity of youth, fascinated by the wonderful rapidity of discovery and the charms of novelty, may easily be led to confound hypotheses with facts, unless we provide some means for their proper enlightenment. They may also be easily led to see that all truth is harmonious; that there are different kinds of truth, adapted to different spiritual requirements; that the existence, the appreciation, and the authority of truth, are all due to spiritual existence; that spirit is superior to matter; that only through faith in the inspiration of the Almighty is any exercise of our reasoning powers or any attainment of knowledge possible; that faith is, therefore, higher than reason, and it is important that our faith should have the foundation of God, which standeth sure.

Let us not hope or desire to banish either bigotry or radicalism. As long as men differ in taste and ability, they will also differ in their leanings towards opposite extremes of thought. Men of one idea fill a useful place in the economy of culture, for their very extravagance may serve as a warning; their devotion, as an example; their leadership, as an inspiration; their antagonism, as a needful restraint. Few walk so safely in the golden mean, that they are never misled by the mists of error; few can be awakened to a knowledge of their own mistakes, so quickly and so thoroughly, as by wrestling with counter mistakes. He who seeks for a symmetrical growth in truth, should first seek to know himself. If his intellectual vigor is so great as to make him haughty and headstrong, he needs to learn the helplessness of reason and the power of faith; to see that all our boasted intellectual triumphs are limited to the acceptance of conclusions, which rest upon simple faith in propositions that cannot be proved. If his faith in his creed, his teachers or his companions, degenerates into the credulity of ignorance, he needs to learn that faith was given us only as a helper, not as a tyrant; that moral and religious growth should be accompanied by intellectual growth; that worldly probation was designed for the proper exercise and training of all our powers, in order that we may come "unto the measure of the stature of the fulness of Christ;" that a reasonable faith should always be accompanied by a faithful reason.

It is with nations and with ages as with individuals. Each community and each period, represents a certain stage of progress, a certain capacity of development, a certain want of guidance. Although history often seems to repeat itself, each apparent repetition is shaped by new conditions. Old questions are continually coming up, but they are continually answered under new phases of experience. The thoughts of Socrates and Plato have left an impress upon humanity which can never be obliterated; the great religions of antiquity prepared the way for Christianity; the claims of Christianity, as a final and culminating revelation "in the dispensation of the fulness of times," rest on its completeness and on its adaptation to the wants, not of a single age or of many ages, but of all ages. The triumphs of reason, when guided by faith in the intimations of truth which

are given, with more or less clearness, to all men, are shown in the lasting vitality which pervaded the teachings of the great questioner and the "academic swan;" the triumphs of faith, when moulded by the sturdy intellects of skilful priests and devotees, maintained the old religions during their severally allotted reigns; the joint triumphs of reason and faith, under "the shining light, that shineth more and more unto the perfect day," are henceforth to be won by Christian champions, through such diligence of labor and harmony of action, as will promote a thoroughly symmetric spiritual and intellectual growth.

Christianity, as thus interpreted, becomes the culmination of all philosophy, as well as the culmination of all religion, for any system of complete truth must satisfy all the demands of secular investigation, as well as all the needs of eternal warfare. Few, perhaps none, are fully aware of the mighty influence which the Christian training of nineteen centuries has exerted on the habits of thought, and on the mental calibre, of every individual in modern civilized communities. Scoffers, wearied with the inconsistencies which mar the characters of professed religionists, and dazed by the enchantment which is lent by distance, sometimes extol the purity of heathen faiths, or the superiority of philosophical systems to all forms of faith. But impartial observers find in the Bible, as nowhere else, an embodiment of the best truths of all ages, expressed with a grand simplicity which is without parallel, and suitable for a ready application to all wants.

There will always be a large intellectual class, acknowledging an Omnipresent Ruler who is All-loving, Almighty and All-wise, whom they delight to worship as their Heavenly Father, but of whom, through fear of "dividing the substance," they hesitate to speak in terms which might be interpreted as claiming a knowledge of mysteries that are beyond their comprehension. There will always be a much larger class, so filled with a sense of their own weakness and unworthiness, that they yearn after a still closer and, as it were, brotherly relationship of sympathy and suffering, under which they may be emboldened to approach the throne of grace with the prayer of David: "Let the words of my mouth, and the meditation of my heart, be acceptable in thy sight, O Lord, my strength and my redeemer." There will always be a third class, rejoicing in the belief that God is a Spirit, who is to be worshiped in spirit and in truth, who offers them at all times the spiritual guidance which is best suited to their immediate spiritual condition, and who will require nothing at their hands but a simple, childlike acceptance of that guidance and consequent obedience to their clearly perceived intimations of truth and duty. Each of these views is a relative and partial view. In each class there will always be many who think, that even if it should be true that partial truths may answer all the positive requirements, the bare necessities of our nature, such harmonious development of our faculties as is most desirable, can only be attained through the study and acceptance of all the primary phases of belief, and the search for the fundamantal postulates which unite them all and give them all their vitality.

Faith cannot take the place of action or of reason ; action cannot take the place of faith or of reason ; reason cannot take the place of faith or of action. The province of faith is, however, the highest, because it deals directly with eternal verities, and because it furnishes the sole authority for action and reason ; the province of action is next in order of dignity, because it determines character ; the province of reason is the lowest, because it deals mostly with temporal and worldly relations, and because it indicates a defective intelligence, which can only slowly and laboriously reach a clear understanding of the contents of simple intuitions.

None of the facts, either of theology or of metaphysics or of physics, can be gainsaid. Some of them are naturally, and some are spiritually discerned. They may all be KNOWN, because God has revealed himself, not only as Power and as Way, but also as Wisdom and Love, as Truth and Life. In the coincident union of perfect humanity and perfect wisdom is found the Divine image, in which man was made and by which we are able to have the positive assurance, of full and indisputable self-evidence, in regard to all things which God has been pleased to reveal to us and which we are willing to accept. Theories have no binding authority upon any one, and they have no value except as they may be made tributary to the discovery or to the application of new truths or new harmonies. Theologians, metaphysicians and physicists should all be mindful of the behest, "*ne sutor ultra crepidam;*" they should also remember that the best interpretation of any truth is the one which accords most fully with all other truths. The highest philosophy is that which is best fitted for the highest capabilities of immortal intelligence. The surest foundation for philosophy is the one on which Christianity is built, the Rock of Ages, the Eternal Word and Wisdom of God.

Stated Meeting, January 3, 1879.

Present, 5 members.

Vice-President, Mr. FRALEY, in the Chair.

A letter requesting exchanges of Proceedings, was received from Mr. P. Casamajor, Corresponding Secretary American Chemical Society, No. 11 East Fourteenth street, New York City, dated January 1, 1879. On motion the name of that Society was ordered to be placed on the list of correspondents to receive the Proceedings.

A letter requesting exchanges was received from Prof. Carus, editor of the Zoologischer Anzeiger, through Mr. E. L. Mark, Instructor in Zoology in Harvard University, dated 48 Shephard street, Cambridge, Mass., December 23,

1878. On motion the Zoologischer Anzeiger was ordered to be placed on the list of correspondents to receive the Proceedings.

Donations for the Library were received from the Imperial Russian Academy and Geographical Society; the Astronomical Observatory at Dorpat; the R. Prussian Academy; the Austrian Geological Institute, and Geographical and Anthropological Societies; the Societies at Emden and St. Gall; the Annales des Mines, and Revue Politique; the Commercial Geographical Society at Bordeaux; the R. Belgian Academy; the R. Astronomical, Geological, and Zoological Societies, and London Nature; Mr. James Henry; the R. Irish Academy; the Canadian Naturalist; the Boston Natural History Society; the National Academy of Sciences; the Bureau of U. S. Geological Surveys of the Territories; Mr. W. H. Howgate; and the Argentine Scientific Society.

The death of Dr. Carl Friedrich Rokitansky, at Vienna, July 23, 1878, was announced by the Secretary.

The death of Dr. Hermann Lebert, at Vevay, was reported from Leipsig, by Dr. Felix Flügel.

The report of the judges and clerks of the annual election was read, by which it appeared that the officers and members of Council for the ensuing year, were elected as follows:

President.

George B. Wood.

Vice-Presidents.

Frederick Fraley, Eli K. Price, E. Otis Kendall.

Secretaries.

J. L. LeConte, Pliny E. Chase, George F. Barker, J. P. Lesley.

Councillors for three years.

Alfred L. Elwyn, Benj. H. Coates, Benj. V. Marsh. George H. Horn.

Curators.

Hector Tyndale, Charles M. Cresson, Daniel G. Brinton.

Treasurer.

J. Sergeant Price.

Pending nominations 871, 872, 873 were read.

Mr. Lesley was nominated as Librarian; and the meeting was adjourned.

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*A Contribution to the Geology of the Lower Amazonas.**

By Orville A. Derby, M. S.

(*Read before the American Philosophical Society, Feb.* 21, 1879.)

In the following sketch of the geology of the region of the Lower Amazonas I have attempted to give a résumé of the most important results of the studies made by, and under the direction of, the late Prof. Ch. Fred. Hartt, in whom Science mourns the loss of one of its brightest ornaments in North America, and of its chief and ablest expounder in the southern continent. It is, for the most part, condensed from an extensive report, prepared by Prof. Hartt as chief of the Geological Commission of the Empire of Brazil, the publication of which has been delayed, in consequence of the financial condition of the Empire and of the untimely death of the chief of the Commission.

The history of the explorations on which this sketch is based is briefly as follows: In 1870, Prof. Hartt, with a party of students, visited the Amazonas, ascending the Tocantins and the Tapajos to among their lower rapids, and examining the high lands of the vicinity of Santarem, Monte Alegre and Ereré. In the following year he returned, accompanied by myself, re-examined the Ereré and Tapajos regions and explored the table-topped mountains between Prainha and Monte Alegre, sending me, in the meanwhile, to Obydos and afterwards to the island of Marajó. These explorations gave rise to a number of special papers, published in the American scientific journals. On assuming direction of the Brazilian Geological Survey, Prof. Hartt engaged Mr. Herbert H. Smith, a member of the party of 1870, who was then on the Amazonas, to continue the geological exploration, and he afterwards sent me, with Dr. Francisco José de Freitas, to the same region. Together with these two gentlemen I re-examined the Ereré region, and ascended the Maecurú (Gurupatuba of the maps), as far as the fall called Pancada Grande. After this exploration, Mr. Smith continued the examination, which he had already begun, of the

*A Portuguese version of this report is also being published in the *Archivos do Museu Nacional* of Rio de Janeiro, Vol. II, 1878.

region about Alenguer, ascended the river Curuá de Alenguer as far as the Bem-fica fall, and afterwards revisited the lower Tapajos. Dr. Freitas and myself ascended the Trombetas and I afterwards revisited Marajó. The Devonian fossils have been studied by Mr. Richard Rathbun, while I have myself determined those of the Silurian and Carboniferous.

Having been intimately associated with Prof. Hartt in all the Amazonian work, I can claim but little originality in the conclusions drawn from the observations and presented in this article, the most of them having been presented by my illustrious teacher in his various publications, or brought out in our discussions on the subject, in such a way that it is now impossible to determine the authorship of each idea. The work of the last explorations by Messrs. Smith, Freitas and myself, in which Prof. Hartt, had no part, was mainly the determination of the character and age of the Ereré uplift, and of the extension and relations of the various Palæozoic deposits on the northern side of the Amazonas. It is proper to state that in regard to the Cretaceous age of the Ereré sandstone and the date of the elevation of the anticlinal, Prof. Hartt reserved his opinion for a more careful examination of the evidence that I had to present on that point, than he was ever able to make. I am confident, however, that if he had made such an examination, I should have been able to convince him of the accuracy of my observations and conclusions.

The river known to geographers by the name Amazonas has, like many other rivers, various names which are applied by the inhabitants along its banks to different parts of its course. These popular designations of Amazonas, or Baixo (Lower) Amazonas, Solimões and Marañon, mark approximately three sections of the valley, which are very distinct in physical characteristics and have very different geological histories. They may, therefore, be advantageously retained to designate the lower, middle and upper portion of the great river.

The differences in these three sections are due to the relations of the valley with the component parts of the South American continent; so that in order to understand the structure of the valley, we must bear in mind the general features, long since recognized, of that continent. This is composed of three distinct mountainous regions, more or less united by elevated plains, in which are excavated the great depressions occupied by the fluvial systems of the Orinoco, Amazonas and Rio de la Plata. The Andes form a long, narrow strip of great elevation, along the western coast, and the mountains of Brazil and of Guiana, considerably less elevated than the Andes, occupy extensive areas in the eastern and northern portions of the continent. The space between these three elevated regions or nuclei of the continent is occupied by vast elevated plains, generally less than three thousand feet high, except in a narrow strip between the highlands of Brazil and Guiana, in which the continuity of the plains is entirely interrupted by the depressed valley of the Amazonas. It is also to be noted that between the Andes and the two elevated regions of the eastern part of the continent, the continuity of the plateaux is almost de-

stroyed by the great cuts made by the Rios Paraguay and Madeira in the south, and the Rios Negro and Orinoco in the north, and only a comparatively slight continental depression would be required to entirely separate these regions. In fact, the region of Guiana may be considered an island, in consequence of the existence of that geographical phenomenon, the Cassiquiarí, uniting the Orinoco and Rio Negro.

The Amazonas, unlike the Orinoco and the La Plata in this respect, has relations with all three of the mountainous regions above indicated. The upper part, or Marañon, belongs exclusively to the Andes; the middle, or Solimões portion, is in the region intermediate between the Andes and the highlands of Brazil and of Guiana; and the Lower Amazonas, from the mouth of the Rio Negro to the sea, is between these two last masses of highlands.

From a purely geographical point of view, the Lower Amazonas and the Solimões might be united in a single section, because the differences between these two portions are, at present, much less than those between the Marañon and the rest of the great stream. Taking into consideration, however, the geological structure, and especially the conditions which geology shows to have existed in former times, it will be seen, as I hope to prove, that this division of the valley into three sections is a natural one.

An examination of the hydrography of the Amazonian basin, taken as a whole, reveals much more noticeable differences in the three portions than are seen in the valley properly so called. The Marañon and its great southern tributaries in the Andean region, the Huallaga and the Ucayael, descend from great elevations in the cordilheiras, and flow northerly in the general direction of the trend of the mountains, until, escaping from them, the Marañon takes an easterly direction, in which it presents a notable contrast with the Ucayale which, although it has descended to a comparatively low level, a long distance above its mouth, still continues to flow in a northerly direction, as if it were forced for some reason, to follow the margin of the mountainous region. The northern tributaries of the Marañon, including the Napo which empties nearly opposite the mouth of the Ucayale, descend from the Andes of Equador in a south-easterly direction, directed by the slope of the mountains. The area drained by the Marañon and its tributaries is very long in the direction north-south, but very narrow in the direction east-west.

In the Solimões region, on the contrary, the region drained on the north is rectangular in shape, the longest axis of the rectangle extending east-west, parallel with the river, and the tributaries in this region, including the Rio Negro, flow in valleys of slight elevation in an easterly direction, subparallel with the Solimões, as if they were crowded down towards the south, and directed in their courses by a line of highlands, uniting the mountains of Guiana with the Andes. The southern area, drained by the Solimões and included between the Ucayale, the Madeira, and the eastern prolongation of the Andes in Bolivia, is of triangular shape. The tributaries in this area rise in the plateau east of the Andes, at moderate eleva-

tions (the source of the Purús is according to Chandless at an elevation of only 1,088 feet above the level of the sea), and, as Chandless has already pointed out, flow in their upper courses in a general easterly direction, as if directed by an imperceptible slope from the Andes.

In the Lower Amazonas region, the mountains of Guiana are comparatively near to the river, and, in consequence, the northern tributaries are small and flow directly towards the main river, with a slight deflection towards the east. On the southern side, on the contrary, the great plateau of central Brazil extends from near the Amazonas to the headwaters of the Paraguay and the mountains of Goyaz. The great tributaries, Tapajos, Xingú and Tocantins, traverse this plateau in a northerly direction, and descend to the level of the Amazonas by a steep incline that commences a short distance above their mouths. I have purposely omitted to mention the Madeira, because this river is related to all three of the sections of the basin. One of its tributaries, the Guaporé, rises in the highest part of the central plateau of Brazil, and appears to flow along a margin of that plateau (the so-called Cordilheira de Parecis), until it joins the Mamoré which, like the Beni and Madre de Deus, descends from the high Andes of Bolivia, circling round the great eastern projection of the Andes, in the district of Santa Cruz de la Sierra. The lower Madeira, which forms the division between the regions of the Solimões and the lower Amazonas, flows northeasterly, subparallel with the great features of eastern Brazil, viz: the mountain chains of the coast and of Minas Geraes, and the valleys of the upper São Francisco and upper Paraná. Farther on I shall have to speak of the significance of this fact.

Let us now consider in greater detail, the physical and geological features of the Lower Amazonas region, the immediate subject of this article. What most impresses the traveler on the Amazonas, after the enormous extension, width and volume of the river, the labyrinth of its side channels and the richness of its flora, is the great extent of the *varzea* or flood-plain that, monotonous as the sea, accompanies the river in a broad belt on each side, from the mouth to the foot of the Andes. Being generally well wooded, the forest gives this flood-plain a false appearance of dry land, and the traveler is very liable to be deceived regarding its true character and extent. To form a true estimate of its importance, it is necessary to ascend one of the few eminences which occur along the margin of the river, as those of Monte Alegre, Santarem and Obydos. From these elevations there is seen a great marshy plain, almost on a level with the river, diversified with lakes and island-like groups of trees, and intersected by numerous anastomosing lateral canals, *furos* or *paraná-merins*, which plain extends for many miles to the highlands of the opposite side, visible in the distant horizon. In this vast plain, the river, great as it is, appears a narrow ribbon of water, almost lost in the immensity of its ancient bed, for the *varzea* can only be considered as a portion, which has been filled up, of the original bed of the river, or, rather, of the estuary which preceded the riverine condition. In this great depression, the river curves from side

to side, now approaching one bank, now the other, but rarely reaching the foot of the highlands, except at a few points in the vicinity of Santarem and Obydos.

Below the mouth of the Xingú, the *varzea* which, with rare interruptions, forms the banks of the river, as well as the innumerable islands (with the exception of the eastern portion of Marajó), is densely wooded, the rubber tree being particularly abundant and characteristic. From the same point to the mouth of the Rio Negro it is frequently open, and covered with coarse grasses and marsh plants. In certain parts, as in front of Santarem and Obydos, it is sufficiently high along the margins of the river and canals, to be above the reach of the ordinary annual floods, and in these parts there are a few plantations of cacáo, and some cattle farms; but for the most part the *varzea* is uninhabited, excepting for a few months during the rubber season, in the wooded portions, and during the dry season, in the region of the open plains, when the herds are driven from the highlands to take advantage of the pasturage. Besides margining the main river, the *varzea* extends innumerable branches into every break in the margin of the highlands, produced by the valleys of the tributaries, whose own flood plains are so closely united to that of the Amazonas, that it is often difficult to determine where the valley proper of a tributary terminates and where that of the Amazonas begins.

The highlands or *terra firma* are very variable in character and elevation, but may be classed in three divisions, viz: low plains, high plains, and irregular or mountainous regions. The first, having only a few feet of elevation above the *varzea*, are slightly developed in the lower Amazonas region, above the mouth of the Xingú; but from that point to the sea, the low plains are of considerable extent and importance, forming the campos of the island of Marajó and a wooded belt on each side of the river, which belt, in the vicinity of Pará, has a considerable extension towards the south. The elevated plains lie on the southern side, at a considerable distance back from the river, behind the low plains just mentioned, in the region about Pará; but to the westward they approach more and more nearly to the river, until finally they appear on its banks, in the bluffs of Cuçury, a little below Santarem, and afterwards on the same side, in the Serra dos Parintintins, near Villa Bella. On the northern side they form a series of high table-topped hills, which, lying a few miles back from the river, commence almost in front of the mouth of the Xingú, and, under the names of Serras de Almeirim, Parú, Velha Pobre, Parauáquára, etc., extend westward behind Monte Alegre as far as, or beyond, the river Trombetas. The same plains appear also in the lower highlands of Monte Alegre and Obydos.

Where they have not suffered denudation these plains form table-lands, highest on the northern side of the river, where those just mentioned reach an elevation of about 1,000 feet, while those of Santarem and others on the southern side have less than half this elevation. In many regions they have been reduced by denudation to low, gently undulated plains, like those

of Prainha, Monte Alegre, Santarem and Obydos, in the midst of which there appears occasionally a conical or flat-topped peak, to attest t' e original character of the plain and the extent of the denudation. The table-lands and their slopes are generally wooded, while the lower undulated plains are open and grassy, covered with a barren soil of loose sand. In the interior, on both sides of the river, these table-lands appear to rise gradually in height, until they become united with the more elevated plains of central Guiana and Brazil.

The last division of the highlands, that of the hilly or mountainous country, is represented, near the northern bank of the Amazonas, by an isolated group of mountains, in the vicinity of Monte Alegre and Ereré. These rise abruptly in the midst of a plain to a height of 1,000 feet, and are, in general, rocky or sandy and barren. Associated with these mountains and having the same geological structure is a low, stony campo. Ascending the tributaries on both the northern and the southern side, there is found, in the regions of the rapids, at a distance varying from 50 to 200 miles from the main river, a hilly country, whose highest points are, in general, lower than those of the Ereré group of mountains. These hilly regions are usually well-wooded, with many valuable kinds of timber, the Brazil and sapucaia nut trees (*Bertholletia excelsa* and *Lecythis grandiflora*) being very abundant and characteristic. To these hilly regions succeed, on the north, the high mountains of Guiana and, on the south, the table-lands of central Brazil.

The differences above noted in the different regions of the highlands or *terra firma* depend on the geological structure of the valley, and before describing minutely the different formations, it may be well to present a general sketch of the geology of this part of the valley, and indicate the relations of the regions above described.

Prof. Hartt has well described this structure as follows;* "The Amazonian valley first appeared as a wide strait between two islands or groups of islands, one now forming the base and nucleus of the Brazilian plateau, the other, on the north, the plateau of Guiana. These islands first appeared at, or shortly after, the beginning of the Silurian Age."

In this canal, before the elevation of the Andes, were deposited a series of beds, representing the Upper Silurian, Devonian, Carboniferous and Cretaceous, which appeared successively in dry land on each side, narrowing the strait between the two islands. Prof. Hartt continues: "Before the rise of the Andes the valley of the Amazonas consisted simply of two gulfs united by a narrow strait. The Andes were thrown up across the mouth of the western gulf, converting it into a basin, though it probably had an outlet both to the north and south. The whole continent was afterwards depressed, so that the waters covered widely the Guayanian and Brazilian plateaux, and the Tertiary beds were deposited there, varying in thickness, coarseness or fineness, according to the conditions under which they were formed. * * * *

* Journal of the American Geographical Society, Vol. III, p. 231, 1872.

"When the continent was once more brought above water, the plateaux, leveled by their new acquisition of strata, first rose; but, by and by, the present water sheds, joining the great plateaux with the Andes, came above water and the Amazonian valley became a Mediterranean, communicating eastward with the Atlantic by a narrow strait. The soft Tertiary beds of the province of Pará were rapidly denuded by the action of the sea during the rise of the land. Probably, while Guiana existed as an island, the Amazonas felt the influence of the equatorial current, which may have aided in carrying away the results of denudation. In the end, the Tertiary beds were completely swept away over an immense tract of country; the Serras of Parú and the similar mountains to the northward were left as monuments of their existence. * * * While the Tertiary sheet was being denuded away, the streams from the highlands were cutting for themselves valleys through the same beds, and these, forming estuaries, were widened to a greater extent than it would have been possible for the streams themselves to have done. During this epoch of denudation deposits were formed, not only in the interior sea, but also in the gulf into which it opened to the east. * * * As the rise continued, the interior sea, now shallowed by much sediment and freshened by the tribute of a thousand streams, was rapidly narrowed in area, and the river Amazonas, properly speaking, which hitherto emptied into a lake at the foot of the Andes, began to extend its channel, following the retreating waters."

The above quotation explains clearly the origin of the *varzea*, of the low plains of Pará, and of the higher plains of the interior of the province. In the hilly regions the inclined beds of the formations older than the Tertiary, including the Cretaceous, the Palæozoic and the Archean, appear in virtue of the denudation of the overlying Tertiary sheet.

The rocks of the ancient islands, the first lands that appeared in the ocean in which the continent was forming, have been profoundly metamorphosed, being converted into granite, gneiss, quartzite and metamorphic schists, and by reason of this, the extent of these islands may be approximately determined by the study of the distribution of the metamorphic rocks. Those of the north appear in the high mountains of Guiana, along the boundary between Brazil and Guiana and, decreasing in elevation towards the south, extend to a line that, beginning near the Atlantic and the mouth of the Amazonas, in about latitude 1° N., extends a little south of west, to the confluence of the Rio Branco and Rio Negro, between latitudes 1° and 2° S. Along this line, which represents the ancient coast, the metamorphic rocks are in general only exposed in the valleys, by the denudation of the Tertiary beds. To the west of the mouth of the Rio Branco they extend to, or beyond, the upper Rio Negro.

On the Brazilian side, the metamorphic rocks only form high mountains in regions far distant from the Amazonas; but they are met with under the other formation in the greater part, if not in all the elevated portions of Brazil. In the Amazonian region, they form the rapids of the rivers Tocantins, Xingú, Tapajos and Madeira, the line of exposures passing the

Tocantins between 3° and 4° of south latitude, the Tapajos between 4° and 5°, and the Madeira between 8° and 9°, at the rapids of São Antonio. The lower Madeira appears to mark approximately the western limit of the ancient metamorphic region, because in the next river to the westward, the Purús, the rocks under consideration were not met with by Chandless, in the course of his careful exploration. The parallelism of the course of the lower Madeira with the great surface features of eastern Brazil, where the metamorphic rocks are thrown into great folds, trending north-easterly, has already been noted. It seems possible that the Madeira is directed by such a fold, or, what is more probable, by a margin of the metamorphic region, which should there have that direction. It is possible that the Guaporé also marks another margin of the same region, which being transverse to the folds is independent of their trend. It is certain that in the Guaporé region there was a canal between the metamorphic region of Brazil and a similar one in Bolivia, the Chiquitos region of D'Orbigny, comparable with the strait between Brazil and Guiana, now occupied by the Amazonas.

As in eastern and central Brazil, the metamorphic rocks of the Amazonian region can be naturally divided into two very distinct series, of which one, the most ancient, consists of crystalline rocks, including gneiss, gneiss-granite and syenite, and the other, more modern, of altered, but in general non-crystalline rocks, consisting of quartzites, metamorphic schists and crystalline limestones. The older series corresponds in character and geological age with that of the Serra do Mar and Serra do Mantiqueira, in the provinces of Rio de Janeiro and Minas Geraes, which was referred by Prof. Hartt to the Laurentian. This series has been but little studied in the Amazonian region. Castelnau speaks of gray gneiss on the Tocantins above the first rapids, and Chandless met with gneiss in a similar position on the Tapajos. Sñr. Ferreira Penna, of Pará, informed me that the rapids of the Xingú are formed by gneiss and diorite, and showed me specimens of the first, consisting of flesh-colored feldspar and quartz with a small proportion of black mica, the rock in hand specimens appearing massive and granitoid. The lower rapids of the Madeira are also formed of gneiss, but I have seen no specimens or descriptions of the rock. On the northern side, gneiss was met with *in situ*, by Sñr. Penna, in the rapids of the Araguary, a small river emptying into the Atlantic, a little to the north of the mouth of the Amazonas, and pebbles of the same rock were met with in the explorations of the Geological Commission, on the rivers Maecurú, Curuá, and Trombetas. I am informed by the engineer, Maj. Coutinho, that gneiss is the prevailing rock on the Rio Branco, except at the mouth, where he found red syenite. I found this last rock also in a zone about half a mile in width, at the second rapid of the river Trombetas, and saw pebbles ofthe same on the Maecurú, coming from some point above that reached by our explorations. I could not determine, in the short time at my disposal on the Trombetas, whether the rock is stratified or not, and it is possibly of eruptive origin. The syenite consists princi-

pally of flesh-colored feldspar, with a small mixture of hornblende and small scattered spots of a green mineral in decomposition. Quartz is entirely lacking.

The rocks of the second metamorphic series are well exposed in the first rapids of the Tocantins, where they were examined as far as the Cachoeira de Guariba, by Prof. Hartt in 1870. The following notes are taken from his manuscripts. Ascending the Tocantins, the river is at first margined by bluffs of Tertiary sands and clays which, as the rapids are approached, recede from the river and the metamorphic rocks begin to appear. The first exposure of these last met with, is "A granular quartzite, very hard and with a saccharine fracture, the rock being much traversed by quartz veins. The stratification is very obscure and the rock appears to have a sort of slaty structure. In some places it is very compact, bluish and cherty, and is so cut up by veinlets as to appear honey-combed on decomposition. Next appears, at the Ponta do Noberto, a talcose rock, badly decomposed, but appearing to have an easterly dip. Above this is a bed of compact reddish quartzite. From the Praia dos Mortos there extends a long line of similar rocks, with an easterly dip. At Jequirapuá, I found the following section, given in ascending order:

1. Shaly sandstone.
2. Compact white sandstone, rather fine grained, the grain being clear. It weathers brownish, and is traversed by quartz veins.
3. A thin band of purple shale, stratification obscured by faults and oblique slips.
4. Heavy band of ferruginous shale, much decomposed.
5. Bed of very compact bluish, whitish and reddish mottled quartzites.
6. Red shale much traversed by little veins. Just below Alcobaça, I observed quartzite with a north-east dip. At Alcobaça are heavy beds of bluish quartzite, very hard and presenting surfaces polished by the river."

Compact quartzites were observed at various points above Alcobaça, in one place with the strike corresponding with the direction of the river, forming long rocky islands or lines of rock. The dip is well marked, being a few degrees north of east, the angle being about 40°.

"Just below the Cachoeira (rapid) de Tapanhúaquára are green schistose rocks, dipping eastward, and much diorite. In the schists I found amianthus and serpentine. The rocks that choke up the river and form the rapids are, as far as I could determine, a series of gray quartzites, interstratified with thin beds of finely laminated shale. The upper end of the high wooded Ilha das Pacas is composed of a mass of hard, vitreous-looking, bluish or reddish quartzite, much traversed by little quartz veins. On the left bank opposite are ledges and skerries of a slaty rock, with a strong easterly dip. The islets of Janaúquára are bare masses of a hard cherty rock, whose relations to the other rocks I did not determine.

"At Porta de Braga, a bluff projection on the left bank of the river, the shore is encumbered by very large masses of iron ore, in part a mammillary hematite. The rocks of the vicinity, consisting of quartzites and sand-

stones, have a strong easterly dip. As I remember it, the deposit appears to be superficial, and I doubt if it is of economic value.

"Opposite the Praia Grande is a very long narrow line of rocks, running south a few degrees east, and flanked by the schistose rocks, which here present the ordinary eastward dip. The line of rocks is formed by a narrow outcrop of diorite, which I suspect to form a dyke. This diorite is much cracked and, decomposing concentrically, the fragments give rise to a confusion of rounded blocks.

"Near by, the slaty rocks again appear, with the cherty rocks apparently overlying them in discordance of stratification. These latter rocks may therefore be of much later origin. In one place I thought that I observed signs of horizontal stratification. Near the upper end of an enormous sand bank, called Praia Grande, the slaty rocks crop out again, the strike being N. 30° W. and the dip 27° E.

"The Cachoeira de Guariba is formed by the outcrop of a series of metamorphic rocks, an alternation of shales, quartzites and limestones, extending across the river, forming a sort of dam. The strike here is somewhat irregular, but usually a few degrees west of north, the dip being eastward and at a moderate angle. I could not ascend above the Cachoeira de Guariba, from lack of time and of a proper boat. From all that I was able to judge, the metamorphic rocks must extend much further up the river, and it would be very important to have them examined. Whether the whole series that I saw belongs to the same geological horizon or not, I was unable, in the absence of fossils, to determine, but, after my studies of the Carboniferous and Devonian of the Amazonas, I think there can be little doubt that the series is Silurian.

"It is interesting to note the dip of these rocks, which is pretty constantly towards the east, the strike being remarkably northerly. The fact of the occurrence of trap dykes is also important. I saw no porphyries like those of the lower falls of the Tapajos, and I cannot help thinking that the Tocantins beds above described are newer than those of the Tapajos."

The metamorphic rocks of the rapids of the Tapajos were described by Prof. Hartt in the Bulletin of the Cornell University. They consist of quartzites and other rocks similar to quartzites, but without apparent granulation, the beds being traversed by enormous dykes of porphyry and diorite. They are very compact, of a red or chocolate color, frequently marked by little green points, due to some undeterminable mineral in decomposition. In hand specimens the amorphous rocks appear to be igneous, a few scattered crystals of feldspar giving them the appearance of porphyry; but seen in mass, the water-worn surfaces show with great distinctness, lines of lamination and wave and ripple-marks, which prove conclusively the sedimentary origin of the rock. The beds are inclined 15°–20° S. E., the strike being N. 30°–40° E.

The porphyry of the dykes is evidently eruptive. It consists of a compact, amorphous, feldspathic base of a dark chocolate color, in which are scattered crystals of red feldspar, rounded grains of quartz and little

masses of the green mineral above mentioned. There was also observed in the cachoeiras, two exposures of crystalline rocks which appear to form dykes, but this character was not well determined. One of these is fine-grained and dark-colored, the other consists of light-red feldspar, with grains of quartz.

We found on the Trombetas a series very similar to a part of that of the Tapajos. It is exposed in the third cachoeira, called Quebra-potes, and also in the lower course of the river Cachorro, which empties into the Trombetas just above that cachoeira. The rock varies in color, some beds being dark red, others purplish, and like that of the Tapajos it is marked by green spots. The mass is amorphous, feldspathic, sometimes with small grains of glassy quartz, and it may be classified as felsite or eurite. The stratification is very distinct, and the lamination, wave and ripple-marks are as clearly shown as in any modern sandstone. The beds of felsite rest on those of the syenite already described, which is also marked by green spots, and dip 20° N. E., the strike being N. 30° W. Resting unconformably on this series are beds of sandstone, containing Upper Silurian fossils.

This last observation is important, proving as it does that the metamorphism of the rocks and the dislocation of the beds must have taken place during the Lower Silurian or Archean. I am convinced that this conclusion can be extended to the whole metamorphic region. The similarity on lithological characters of the rocks of the Trombetas and those of the Tapajos is such, that it can scarcely be doubted that the formations in the two localities are identical. The difference in strike, from N. N. W. on the Trombetas, to N. N. E. on the Tapajos, can readily be admitted in a single system of upheaval, which can include also the disturbed rocks of the Tocantins, where the strike is N. or N. N. W. It should be observed that, while the compact quartzites of the Tocantins resemble the rocks of the Tapajos and Trombetas, the rest of the Tocantins series, consisting of granular quartzites, talcose schists, and crystalline limestones, recall the rocks of the rivers Araguay, and upper Tocantins, and of the mountains of Goyaz and Minas Geraes.

It has long since been observed that the metamorphic rocks of Brazil, Guiana and Venezuela have in general a north-easterly strike; later observations, however, have shown that the strike is often variable, frequently taking a north westerly direction. It seems probable, therefore, that the epoch of metamorphism and upheaval of the ancient rocks was the same in eastern Brazil and Guiana as in the Amazonian region, that is to say, it was anterior to the Upper Silurian.

The evidence in respect to the epoch of metamorphism and upheaval afforded by other regions of Brazil is very scanty, but, as far as it goes, it sustains this generalization, although it must be confessed it is as yet insufficient to entirely confirm it. In the provinces of Bahia and Sergipe there is a series of beds of undetermined age, but which appears to be either Devonian or Carboniferous. These beds have been disturbed without being metamorphosed, and they rest unconformably

on gneiss, and are overlaid unconformably by Cretaceous deposits. The metamorphism of the gneiss in this region was, therefore, early Palæozoic or Archean. In the southern provinces, the evidence is more conclusive. In Santa Catharina and Rio Grande do Sul, beds, whose Carboniferous age appears to be well proven, lie horizontally above inclined metamorphic beds. These Carboniferous deposits extend across the province of Paraná to the southern part of the province of São Paulo. Near Ponta Grossa in Paraná, Mr. Wagoner, assistant to the Geological Commission, found, underneath the Carboniferous beds, others, also horizontal, containing Devonian fossils. In that region, therefore, we may refer the upheaval and metamorphism to a period anterior to the Devonian, and probably, as on the Amazonas, to one anterior to the Upper Silurian.

We have seen that the metamorphic rocks present two distinct series, of which one, consisting of crystalline rocks, was, with all probability, referred by Prof. Hartt to the Laurentian. It is probable that this series had been metamorphosed and disturbed before the deposition of the second non-crystalline series. It is true that there appears to be a concordance in stratification between the two series, but it is by no means certain that this concordance is perfect, and that the older series had not been disturbed (probably in the same general direction), before the great general movement of upheaval, which affected and gave character to the whole metamorphic region of Brazil, if not of the entire continent.

In regard to the age of the second metamorphic series, we have by elimination reduced it to the ages intermediate between the Laurentian and the Upper Silurian, that is to say, the Huronian and the Lower Silurian. It seems probable that both are represented, and, accepting Prof. Hartt's supposition, that the rocks of the Tapajos are more ancient than those of the Tocantins, we may provisionally refer those, with the felsites of the Trombetas, to the Huronian, and these to the Lower Silurian, a reference which accords with another opinion of Prof. Hartt, that is, that the granular quartzites (itacolumites) and talcose schists of Minas Geraes belong to the Lower Silurian.

At the end of this movement of upheaval and folding, the primitive islands of Brazil and Guiana had received enormous additions to their original areas, and extended to the limits already indicated, in treating of the distribution of the metamorphic rocks, leaving between the two islands a strait, some three or four degrees of latitude in width, in the narrowest part. From that time, which was during, or at the end of, the Lower Silurian commenced the proper history of the Amazonian valley.

In this strait was deposited, without great oscillations of level or upheavals, comparable with those that had disturbed the metamorphic series, a series of beds gently inclined from the margins towards the center, representing the formations from the Upper Silurian to the Cretaceous, inclusive. There were, however, before the deposition of the Tertiary beds, considerable eruptions of trap and diorite, and local disturbances in at least one region, that of Ereré. This region is so important in the study of the geology of the Amazonas, as to merit special description.

Situated on the margin of the *varzea*, and about two leagues to the westward of the village of Monte Alegre, there is an isolated group of mountains, consisting of numerous, small monoclinal ridges, separated one from another, and disposed in an ellipse around a central plain, of which the elevation is a few feet at most above the level of the Amazonas. The major axis of the ellipse is some ten or twelve miles long, and lies in the direction of E.–W. The principal mountain, called Serra de Tajurí, is about 350 metres high, and is situated on the north-east side of the ellipse ; from Tajurí, a curved line of low ridges extends to the second serra in size, that of Ereré, which is on the southern side, and has an elevation of 250 metres ; then come the smaller serras of Aroxí, Maxirá, Paraizo, Julião and Urucury, the last being placed at the western end of the ellipse ; between this and Tajurí there is a considerable number of low serras, without names, which have never been explored. All of these serras present an abrupt slope towards the central plain, and a gentle slope, following the inclination of the strata, on the opposite side. This inclination, which varies from 10° to 20°, is N. N. E. in Tajurí, E. in the ridges between Tajurí and Ereré, S. in this last, and W. in Urucury. This variation in dip proves that this group of mountains is only the remnant of a great anticlinal, of which the central, and by far the larger, part has been denuded away. This opinion, respecting the structure of the region, is supported by the structure of the low Serra de Paitúna, which is situated outside of the ellipse, some three or four miles to the south of the Serra de Ereré, with which it is parallel. As was to be expected from its position in relation to the other mountains, Paitúna was found to be a synclinal ridge. It is possible that to the northward of Tajurí there are other synclinal ridges, similar to Paitúna.

There have not yet been definitely recognized in other parts of the valley, any elevations, corresponding in age and structure to those of Ereré. I have reasons, however, for believing that, in the vicinity of Obydos, the Serra de Curumú and perhaps that of Cunury may belong to the same system. Near the margin of the metamorphic region, on the Guiana side at least, the Palæozoic beds are gently inclined, at an angle of 5°–10° ; but in general these beds appear to lie horizontally.

The first member of this Palæozoic series of the Amazonas is the Upper Silurian. The rocks of this age appear on the Guiana side, in a belt of a few miles in width, which extends in the direction east-west for a considerable distance, if not along the whole southern margin of the metamorphic region of Guiana. They have been recognized on the Trombetas, Curuá and Maecurú, and from specimens brought by Sr. Ferreira Penna, from the Maracá, a small river which empties nearly opposite the western end of Marajó, I judge that they extend eastward nearly to the Atlantic.

These rocks have been best studied on the Trombetas. They there appear in a belt four or five miles wide, forming the first and part of the second cachoeira. They were also found, well exposed, in a hill of some 100 metres of elevation, called Oiteiro do Cachorro, situated on the right bank of the river of the same name, a little above its confluence with the Trom-

betas. The lower part of this hill is composed of felsite, above which the Upper Silurian beds form a magnificent overhanging cliff. In the lower part of the second cachoeira, called Vira-Mundo, the Silurian beds rest on syenite. The dip is approximately 5° S. S. W., the strike being N. 65° W. I estimate the total thickness of the series at about 1,000 feet.

The character of the beds is remarkably uniform. They consist almost exclusively of hard argillaceous and micaceous sandstones, generally thin-bedded, but with some massive beds of pure sandstone. The color is very variable, being white, yellow, red or purplish, but the predominant color is some shade of red, generally mottled or banded. Limestones are entirely lacking, and schists are rare and of slight importance, as regards their thickness, but interesting on account of their peculiar characters. One set of beds of cherty schist, about 20 feet thick, is found at the base of the series, in contact with the syenite. This rock looks like one that had suffered some alteration, and this appearance might be taken to prove that the syenite is of igneous origin, and that it had been ejected after the deposition of these beds, effecting an alteration in them. As, however, the altered appearance is less marked in the part of the schists which is in immediate contact with the syenite, than in the upper portion of the bed, I believe that their peculiar appearance is due to some other cause. Another schist of undetermined thickness occurs at the base of the cliff, forming the front of the Oiteiro do Cachorro. It consists of a soft clay, impregnated with alum, which also occurs abundantly in free crystals.

At the foot of the Cachoeira Vira-Mundo, and just above the cherty rocks above mentioned, there is a bed of fine-grained, yellowish sandstone, containing a few fossils of which we collected with considerable difficulty sufficient to determine the age of the formation. The fossils are all in the state of casts and, except a species of *Beyrichia* and a fragment of a Trilobite, are all Molluscan. The most common is an *Orthoceras*, which is however indeterminable. The genera, *Rhynchonella*, *Orthis*, *Chonetes*, *Strophodonta*, *Lingula*, *Pholidops*, *Bucania*, *Conularia* and *Ctenodonta* are represented. Among these the species *Orthis hybrida* Sow., *Lingula cuneata* Conrad, and *Bucania trilobata* Conrad are recognizable. In the Oiteiro do Cachorro are thin beds of shaly sandstone, with well marked fucoids, apparently of the species *Orthrophychus Harlani* Conrad. These fossils indicate a close correspondence with the Medina sandstone of the Niagara group. Throughout the whole series worm-tubes are abundant.

The same series of beds were met with on the Curuá and Maecurú, with characters identical with those just described for the Trombetas. On these rivers the Silurian rocks form cachoeiras, that were impassible with the means at our disposal, and for this reason we did not succeed in reaching the base of the series, where the fossiliferous beds occur. Worm-tubes and indeterminable fucoids were, however, met with. The Upper Silurian has not yet been recognized on the southern side of the valley, but, as all the sections on that side are very incomplete, it is by no means certain that they do not exist. It is possible that the cherty beds of the Tocantins,

mentioned by Prof. Hartt, may belong to this series; but as cherts are common also in the Devonian and Carboniferous, it is impossible, in the absence of specimens, to form a definite opinion respecting the age of those of the Tocantins.

The Devonian is best exposed on the northern side of the valley, where it forms a broad belt, bordering the narrower Silurian belt, and disappears under the Carboniferous deposits, to reappear farther south in the Ereré anticlinal. The beds of this age are variable in character, and may be divided by differences in the rocks and fossils into three groups, which, for convenience, may be named for the locality in which each was best studied, the Maecurú, the Ereré and the Curuá group. It must be remembered, however, that all three of these groups are represented at each of the above localities.

The first, or Maecurú group, consists of a few beds of coarse, white or yellowish sandstone, which, on the Maecurú and Curuá, have a thickness of thirty feet. On both of these rivers this group is well exposed, with a dip of about 5° S. S. W. The rock is hard in some layers, but very friable in others, and is highly fossiliferous. On the Trombetas it is represented by a bed of sandstone, so friable as to be almost a bank of sand, and at Ereré only a portion of the upper bed is exposed, and no fossils were found at either of these localities. The fossils are impressions, colored and somewhat consolidated by oxide of iron; they are beautifully preserved, and so abundant and varied that, with a few hours' work, we made an enormous collection, containing about seventy-five species. Trilobites are represented by species of *Homalonotus*, *Dalmania*, *Phacops* and *Prœtus*; Gasteropods by *Bellerophon*, *Holopea* and *Platyceras*; Lamellibranchs by a large number of species of the genera *Modiomorpha*, *Limoptera*, *Edmondia*, *Grammysia* and others. The most interesting fossils are, however, the Brachiopods, which have been carefully studied by Mr. Rathbun, who has described* twenty-one species from the Maecurú, of which thirteen were also found on the Curuá in equivalent beds, nine in the overlying beds of the Ereré group, and six in the lower and middle Devonian of New York. Of the species common to this group and that of Ereré, those that are abundant in one are generally rare in the other, and this, with the numerous species which are limited to each group, gives a special expression to the fauna of each, which justified their separation. The most abundant and characteristic Brachiopods of the Maecurú group are *Amphigenia elongata* Hall, *Spirifera duodenaria* (?) Hall, *Strophodonta perplana* Hall, *Rhynchonella dotis* (?) Hall, *Vitulina pustulosa* Hall, *Streptorhynchus Agassizii* Hartt, and new species of *Chonetes* and *Orthis*. The two first and the last new species were not met with at Ereré. It will be seen that these fossils indicate a close relationship to the Corniferous group, which bears about the same stratigraphical and palæontological relation to the overlying Hamilton group, as does the Maecurú group to that of Ereré. These last two may, therefore, be considered as the Brazilian equivalents of the North American formations.

* Proceedings of the Boston Society of Natural History, Vol. XX, pp. 14-39, 1878.

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The Ereré group occupies a considerable area in the central plain between the mountains of Ereré, but so sub-divided, denuded and disturbed by eruptions of trap, as to present serious difficulties for study, which were, however, overcome by Mr. Smith in 1876, who succeeded in making a complete section and in proving, by means of fossils, the unity of the group. Mr. Smith calculated the total thickness at about 200 feet, divided between thirteen distinct beds, of which the greater part consist of fine-grained, micaceous sandstone, disposed in thin beds, with subordinate beds of black shale. The sandstone is generally white or yellowish, but exposed to the weather, it becomes reddish, and the shale often weathers white. Near the base of the group there are a few beds of a compact cherty sandstone, that breaks with great regularity into cubical blocks. Fossils are more or less abundant in all of the beds, those of the shale being different from those of the sandstone. The same beds were met with on the Maecurú and Curuá, but less sub-divided, with fewer fossils, and without the shales. The thickness of the group on the Curuá appears to be less than at Ereré. The fauna is very similar to that described from the Maecurú group, but, except in the class of Brachiopods, it is less rich, both in species and individuals. Mr. Rathbun has described twenty-four species of Brachiopods,* two of Trilobites, eight of Lamellibranchs and six of Gasteropods.† Of the first some have already been mentioned; thirteen are limited to this group, of which the most abundant and characteristic are *Retzia Jamesiana* Hartt,‡ *Retzia Wardiana* Hartt, and *Discina lodensis* Hall. *Spirifera Pedroana* Hartt, although it appears rarely in the Maecurú group, is, by its abundance, one of the most characteristic fossils of the Ereré group.

The third or Curuá group consists almost exclusively of black and red shales, passing at times into shaly sandstone. These beds form low cliffs along the rivers Maecurú and Curuá for a considerable distance, lying almost horizontal, except where disturbed by eruptions of diorite. On the Trombetas the black shale forms two short cliffs on the river bank, and the red shale is badly exposed on a lake near by. At Ereré these rocks are exposed in the eastern part of the plain, and in the base of the serras, particularly that of Tajurí, the front of which is composed almost entirely of these shales. The black shale forms the lowest bed, the thickness of which, on the Curuá, is estimated by Mr. Smith at 300 feet. It is well laminated, almost slaty in structure, and in the lower part contains numerous large, calcareous and arenaceous concretions. The first are bluish black in color, have well developed cone-in-cone structure and emit, when struck with a hammer, a strong odor of petroleum.

The reddish shale lies above the black, having more or less the same thickness. It is generally chocolate-colored, mottled with spots of a darker hue and banded, parallel with the stratification, with white, yellow or

* Bulletin of the Buffalo Society of Natural Science, Vol. I, No. 4, 1874.

† Annals of the Lyceum of Natural History of New York, Vol. XI, May, 1875.

‡ It is but just to mention that the gentleman, to whom this species is dedicated, has more than any other, not specially devoted to science, contributed to the progress of geology, not to say of science in general, in Brazil.

black. The rock consists of clay, mixed with a considerable proportion of finely-divided mica and sand, the last often forming independent layers, a few inches thick. The only fossils found in these shales were Fucoids, of the genus *Spirophyton*, and small fruit-like bodies, resembling very much a flattened currant, consisting apparently of a thin pellicle enclosing two to six small grains. The *Spirophytons* are apparently identical with those described by Prof. Hall, from the Hamilton group of New York. They occur abundantly in all the localities, in both the black and red shale, near the junction of the two.

On the Curuá and Maecurú the red shale, which is undoubtedly Devonian, is followed by beds of coarse sandstone which, according to Mr. Smith, are at least fifty feet thick on the Curuá. This is followed by fossiliferous Carboniferous beds. The red shale is also overlaid by coarse sandstone, in the mountains of Ereré, but it is not certain that this sandstone is of the same formation as that of the Curuá.

As regards the extension of the Devonian series, it has been recognized as far west as the river Uatumá, a small river between the Trombetas and the Rio Negro. On the southern side of the valley, there are, on the Tapajos, shales containing *Spirophyton* and calcareous concretions, which were referred provisionally to the Carboniferous by Prof. Hartt, but which seem to me to be Devonian, and I refer to the same age the black shale found by Sñr. Penna on the Xingú.

Of all the Palæozoic deposits of the Amazonas, those of the Carboniferous occupy the most extensive area and, at the same time, present the greatest difficulties to study. Composed for the most part of soft beds, they suffered extensive denudation, during the interval between the close of the Carboniferous and the beginning of the Tertiary, during which time they were, for the most part, exposed above the level of the sea; by the deposit of the great Tertiary series they were concealed, over immense areas, and where they have been again exposed by the denudation of the Tertiary, they have again suffered destructive denudation. At present, the exposures are poor and unsatisfactory, rendering very difficult the determination of the relations of the different beds and the vertical extension of the series. Mr. Smith, who has best studied these deposits, is of the opinion that their total thickness is not less than 2,000 feet, and, although the data for this calculation is very defective, I cannot say that it is exaggerated.

The horizontal extension is more easy to determine. On the Tapajos the rocks of this series appear at intervals, from a point just below the rapids to near the village of Aveiros, a distance of about eighty miles. It is possible that they extend still farther north to near the mouth of the Tapajos, since I am credibly informed that, near Santarem, a bed of limestone occurs, which is most probably of Carboniferous age. To the westward of the Tapajos, they have been recognized by Chandless on the Mauhé-assú, a small river between the Tapajos and Madeira, and I consider it probable that they extend as far west as the latter river. I have information that leads me to believe that they exist to the eastward, on the Xingú, and I

think it probable that they will yet be found on the Tocantins. On the opposite or northern side of the valley, they occur close to the margin of the river, in the vicinity of Alenguer, in front of Santarem, and extend for a considerable distance towards the north, along the rivers Curuá, Maecurú and Trombetas; to the west, they extend at least as far as the Uatumá, already mentioned, and to the east, as far at least as the Jauary, near the village of Prainha.*

The rocks consist of soft shales and sandstone, and of limestone, which last, although of but slight thickness, is the most important, because, having resisted denudation better than the other rocks and being highly fossiliferous, it forms an admirable base of reference in the study of the Carboniferous series. The best exposures of the limestone are on the Tapajos, both above and below the village of Itaitúba, where it is quarried to burn for lime. The thickness is about twenty-five feet, some of the beds being of very pure limestone, of a blue or light brown color, others being darker and somewhat argillaceous and silicious. The fossils being silicified, and consequently more durable than the rock in which they are enclosed, become detached by the slow dissolution of the limestone, and often appear loose, as on the beach in front of Itaitúba. Cherty masses are common in the limestone, and aside from these, two other kinds of chert occur in loose masses which, in the opinion of Mr. Smith, come from some unknown beds above the limestone. One of these kinds decomposes to a white, chalky mass, the other, which forms large, rounded boulders in front of Itaitúba, takes on, in decomposition, the appearance of a porous sandstone. Cherts of various kinds are very abundant in the whole Carboniferous region, and are often highly fossiliferous, but the beds from which they originate are as yet unknown.

Above the limestone at Itaitúba, there are beds of soft, brown sandstone and of shale, of unknown extension, and below there is a heavy series of green, red and black shales, some of which contain *Spirophyton* and are most probably Devonian. Of the Carboniferous rocks of the Mauhé-assú, the only notices we have are of the limestone, which is identical in character and fossils with that of the Tapajos. Passing now to the northern side, we find a thick bed of limestone at the foot of the Serra of Tajurí, in the Ereré region, where it is associated with a yellowish mottled sandstone, much appreciated by the people for whetstones. The exposure, however, in this locality is so unsatisfactory, that it was impossible to determine its relation to the other beds of the serra. In the region between the Maecurú and Curuá, there are exposed, over an extensive area, a variety of beds, which Mr. Smith attempted to arrange in a section which, although somewhat defective, is of considerable interest.

*In this sketch of the character and extension of the Amazonian Carboniferous, I have, aside from the observations of Prof. Hartt and myself, drawn largely from the excellent studies of Mr. Smith on the northern side of the Amazonas, and am also indebted to Mr. Coutinho, the first discoverer of Amazonian fossils, and to Messrs. Chandless, Brown and Rodrigues, for notices of its existence in regions, not visited by the members of the Geological Commission.

On the Curuá, Mr. Smith found, above the beds of undoubted Devonian age, a small series of unfossiliferous sandstones, and then at Praia Grande, loose silicified fossils, identical with those of Itaitúba, which indicate the presence of a bed of limestone. Above this there is a series, the estimated thickness of which is 600 feet, composed of alternations of soft sandstones and sandy shales, of which certain layers near the upper part, exposed at a place called Pacoval, are highly fossiliferous. At lake Cujubim, near the river Maecurú, the section begins below with massive beds of yellow sandstone of undetermined thickness; then comes two feet of hard sandstone, followed by a bed five feet thick, of impure, silicious, fossiliferous limestone, which is separated by ten feet of sandstone and shale from a bed of equal thickness of pure limestone, containing fossils identical with those of Itaitúba; above this are soft beds of sandstone and shale, with fossils identical with those of Pacoval on the Curuá. In various other localities in the vicinity of Alenguer, Mr. Smith found exposures of sandstone and shale of very varied characters, which appear to belong above the series at Cujubim, and to represent, in part at least, the upper portion of the Curuá section. Mr. Smith well observes that the variation in the character of these Carboniferous beds, in both their horizontal and vertical extension, indicates deposition in shallow water, during subsidence. The limestone appears to be always near the base of the series.

The exposures of Carboniferous rocks on the Trombetas are so unsatisfactory, that they scarcely do more than prove the existence there of sandstones, shales and limestones, with fossils identical with those of the other localities.

The Carboniferous fauna of the Amazonas is very rich, containing more than a hundred species of Brachiopods, Lamellibranchs, Gasteropods, Corals, Bryozoans, Echinoderms, Fishes and Trilobites. Of these, I have already published descriptions of the Brachiopods of the Tapajos,* and hope soon to give descriptions of the remainder. The fauna shows the closest relationship to that of the Coal Measures of the Western States, more than half of the species being identical. I have already shown that the Bolivian and Peruvian Carboniferous faunas, as far as they are known, are equivalent to the Brazilian, and to that of the North American Coal Measures.

The following are some of the most important species common to the three regions: *Spirifera camerata* Morton (*S. Condor* D'Orb.), *Athyris subtilita* Hall, *Retzia Mormonii* Marcou (*R. punctulifera* Shumard), *Productus Cora* D'Orb., *Productus semireticulatus* Martin, and *Chonetes glabra* Geinitz. The following are, among others, in addition to the above, common to Brazil and the United States: *Spirifera rockymontana* Marcou, *Spirifera planoconvexa* Shumard, *Spirifera perplexa* McChesney, *Myalina kansasensis* Shumard, *Allorisma subcuneata* Meek and Hayden, *Aviculopecten occidentalis* Shumard, *Aviculopecten carbonaria* Stevens, *Schizodus Wheeleri* Swallow, *Lima retifera* Shumard, *Entolium aviculatum* Swallow, *Bellerophon carbonarius* Cox, *Rhombipora lepidodendroides* Meek, and *Synocladia biserialis* Swallow.

* Bulletin of the Cornell University (Science), Vol. I, No. 2, 1874.

No satisfactory sub-division of the Carboniferous beds of the Amazonas can as yet be made. The fossiliferous beds at the different localities appear to belong to the same limited horizon, and to present always the same fossils. It is true that Mr. Smith found at Curumú and Curucaca, near Alenguer, fossils having a different aspect from those from the other localities, but they are so poorly preserved as to be unrecognizable. The fossils of the calcareous beds are mostly Brachiopods and Corals, while Lamellibranchs are most abundant in the shales and sandstones; but there are many species in common, and the beds are so closely related stratigraphically, that I am inclined to consider the differences in their fossils as due to differences in the nature of the sediments, rather than to a difference in horizon.

While the Palæozoic deposits were being laid down in the Amazonian region, it is to be supposed that the other margins of the ancient Archean and Silurian islands received their quota of deposits and, in fact, in the southern part of Brazil, in the regions now constituting the provinces of Rio Grande do Sul, Santa Catharina, Paraná and the southern part of São Paulo, extensive Carboniferous and Devonian beds were laid down. It is stated also that Carboniferous deposits are to be found in the provinces of Maranhão and Matto-Grosso, on the Guaporé and Upper Paraguay; but, although this seems extremely probable, the fact is not as yet well verified. In the Andean region enormous deposits were formed, during the whole of the Palæozoic. The best known of these are the Carboniferous beds, which appear in the central part of the Cordilheiras, at lake Titicaca, and in the province of Arque in Bolivia; and on the eastern slope of the Andes, at Cochabamba and Santa Cruz de la Sierra, in Bolivia, and on the upper Pachetea, in Peru.

The beds referred to the Cretaceous, have only been recognized with certainty in the mountains of Ereré. We have seen that the Curuá shales of the Devonian series, form in general the base of these mountains. In one place, near the base of Tajurí, these shales are followed by Carboniferous limestones, but in general the Carboniferous beds are lacking throughout the Ereré region, and the Devonian shales are followed by heavy beds of coarse, hard sandstone. In a section made in a hill between Tajurí and Ereré, there are three distinct beds of coarse massive sandstone, separated by beds of micaceous sandy shales, the whole series having a thickness of about 300 feet. Of these three beds of sandstone, the upper or middle, or the two united, form the principal mass of the Serras of Ereré and Paitúna. In the first of these serras were found, in 1871, fragments of fossilized wood, which were referred by Dr. Dawson to the dycotyledonous group of plants, and in the last voyage we found, in Paitúna, a thin bed of argillaceous sandstone, intercallated in the coarser beds of the serra, which was crowded with fossil leaves, belonging to various genera of the same group of plants.

The leaves and woody structure of tropical plants have been too little studied to permit of the specific, and perhaps the generic, determination of these plants. They are, however, of the utmost importance in the

determination of the age of the formation, which can hardly be older than the Cretaceous, and since these fossils are in disturbed beds, which are overlaid by the horizontal deposits referred to the Tertiary, we cannot well consider them as more modern than the Cretaceous.

Fossil leaves, very similar in appearance to those of the Serra de Paitúna, have been found at Tonantins on the Solimões, at Uatapucará on the Tapajos, and at Prainha on the Lower Amazonas, in beds that appear to be Tertiary or recent. A critical examination is required to prove whether or not these fossils from the different localities are identical, or belong to the same horizon. For the present it seems to me most probable that they are distinct, those of Paitúna being the most ancient. It is worthy of note that the fossil leaves at Prainha are in beds of clay and conglomerate that are slightly inclined, and it is possible that, notwithstanding their modern appearance, they may prove to belong to the Cretaceous.

These fossils being in the upper bed of sandstone, the age of the lower beds and of the intermediate sandy shales, between the limits of Upper Devonian and Cretaceous, is undetermined. They are, however, so similar in lithological character, to the fossil leaf beds, that I refer them provisionally to the Cretaceous. What is well proven is, that the elevation of the anticlinal of Ereré took place during, or after, the Cretaceous age. In this connection I may add, that the beds of the numerous Cretaceous basins along the eastern coast of Brazil are always more or less disturbed and inclined.

Near the mouth of the Trombetas we found inclined beds of sandstone, containing pebbles of shale which appear to me to have come from the Devonian or Carboniferous beds, which occur farther up on the same river. In the same region there is a high serra, called Curumú, composed of hard sandstone, the beds of which appear, as seen from a distance, to be inclined, and I suspect that in that region will be found the equivalents of the Ereré Cretaceous beds.

To the south of the mouth of the Amazonas, between Salinas and Bragança, Sñr. Penna has lately discovered fossiliferous limestone, similar to that of the Cretaceous basins of Pernambuco and Sergipe. In the Solimões region there is also, according to Chandless and Coutinho, an extensive Cretaceous area, on the river Purús, characterized by the remains of *Mosasaurus* and turtles.

The disturbances which all the formations thus far described have suffered, were accompanied by eruptions of igneous rocks. In the metamorphic region, the syenite and perhaps a part of the granite may belong to this category, a question that can only be solved by further study. In the same region, and also throughout the Palæozoic region, diorite is very common, forming immense dykes, and sometimes apparently forming sheets between the strata of sedimentary rocks. Another igneous rock of doubtful character, which I have referred to as trap, forms numerous narrow dykes in the Ereré and Alenguer region, traversing both the Palæozoic and the Cretaceous beds. The surface is always decomposed, presenting a

scoriaceous appearance, and enclosing crystals of quartz and fragments of the adjacent sedimentary rocks, these last being often so slightly metamorphosed, as to still preserve traces of fossils. The beds traversed by the dykes are somewhat altered, for a distance of a few feet from the point of contact.

The Tertiary beds have been so often mentioned in the course of this article, that little remains to be said regarding their character and distribution. They are distinguished from those of the older formations by their horizontal position, and by the absence of fossils and of eruptive rocks. They consist of sandstones and clays, of brilliant and varied colors, such as white, red, yellow and blue, combined in different shades, so as to produce a very striking effect in the cliffs, which are very frequent along the tributaries, but rare along the main river. The rock is in general very slightly consolidated, except an occasional bed or patch, in which a cement of oxide of iron has produced the coarse ferruginous sandstone, found scattered over the surface thoughout the whole of the Amazonian highlands.

The Tertiary series is best presented in the serras known under the collective name of Serras de Parú, which are seen from the river, from Almeirim to near Prainha. These are mountains of circumdenudation, perfectly level on top, and of an elevation of about 1,000 feet. The one nearest to Prainha, called Parauáquára, was visited by Prof Hartt in 1871, who found the structure well presented in the steep, bare front of the mountain. The beds, whose thickness corresponds approximately to the height of the mountain, consist of sandstones and clays, of various colors, disposed in nine distinct divisions. From Parauáquára westward, the series of table-topped hills extend for a long distance, but, lying farther back from the river, they cannot be seen, except from some high point as, for example, the mountains of Ereré. From the Maecurú, I saw a rounded peak, rising above the general level, apparently an island of some older formation, in a sea of Tertiary sandstone. In the vicinity of Monte Alegre there are deposits identical in character with those of Parauáquára, which were evidently laid down after the elevation of the Ereré anticlinal. These deposits, like those of Alenguer and Obydos, have suffered a destructive denudation, which has considerably reduced their original height, which probably was never equal to that of the Serras of Parú.

The Tertiary beds of the southern side of the valley, are, in the Santarem region, considerably lower than those of the north, the difference being probably due to the inclination of the bottom of the Tertiary sea, and the smaller quantity of sediment received by the regions farthest removed from the margin of that sea, The highlands behind Santarem are 400 feet high, and do not appear to have suffered denudation that has diminished sensibly their original height. In a bed of blue clay, exposed on the slope of these highlands, I found worm tubes, the only fossils that the Tertiary beds of this region have yet afforded.

This lack of fossils is noticeable, not only in the Lower Amazonian region, but throughout Brazil. In every province there are beds similar in charac-

ter and position to those just described, but so far they have yielded no fossils, that will serve for their classification, and they have been referred to the Tertiary solely on account of their stratigraphical position. The only Tertiary fossils known from this region are the fossil leaves of Tonantins, and the fresh and brackish water mollusks of Pebas and other localities in Perú. These, however, occur in lignitiferous beds, quite different from those now under consideration, and the relation between the two has never so far as I am aware, been satisfactorily determined. The only division that can at present be made in the region of the Lower Amazonas, is between the beds of the high table-lands, and those of the lower plains about Pará and eastern Marajó. These last, consisting of abrupt alternations of coarse and fine sandstone, generally ferruginous, along with colored clays, are certainly more modern than the former, and belong to the later Tertiary or the Quarternary.

During the deposition of the Tertiary, there were considerable movements of depression and subsequently of elevation, but these movements were, as far as is known at present, unaccompanied by disturbances of the strata or eruptions of igneous rocks.

After the elevation of the Tertiary table-lands, began the alluvial deposits of the *varzea*. They consist, according to circumstances and localities, of sands or clays, or a mixture of the two, a yellowish structureless clay predominating, often having above it a bed of black clay, impregnated with vegetable matter. Part of this deposit was without doubt formed in an estuary, while the river was taking possession of the bed prepared for it; but it is now impossible to distinguish the estuary deposits from those that are purely fluvial. The proofs of the estuary condition are not so much in the characters of the deposits, as in the form of the tributary valleys, which are widened in a manner that can only be explained by the action of the tides.

With the formation of the *varzea*, the geological evolution of the valley of the Amazonas terminated. We cannot in this place enter into a consideration of the interesting phenomena, illustrative of Geology and Physical Geography, of which the *varzea* is the theatre. To witness, close at hand, the operation of many of the processes of which these sciences treat, and which have given form and character to the surface of our planet, I know of no region equal to the Amazonas. Between the water and the land, the river and the *varzea*, there is a constant conflict. Islands are formed and destroyed, or floated bodily down stream, by the continual process of destruction at one end, and of formation at the other; lakes, *furos* and *paraná-merins* are being formed, to be again filled up; tributaries extend themselves into the territory proper to the main river, or this throws out one of its lateral channels, to appropriate to itself a part of the valley of a tributary. The conflict, however, is unequal; the force of the river, irresistible as it is in its great floods, is spasmodic in its action, and can be met by a weaker, more constant one, such as is afforded in aid of the growth of the land, by the vegetative force.

PROC. AMER. PHILOS. SOC. XVIII. 103. W. PRINTED MARCH 11, 1879.

Rank behind rank, the various aquatic and marsh plants advance into every shallow, building it up to the common level over which the floods pass, adding new sediment, instead of carrying away that already accumulated. In this way the land is slowly extending itself, confining the river more and more to its proper channel; but this process cannot materially alter the character of the valley, unless aided by some convulsion of nature.

Much yet remains to be done on the Lower Amazonas, in filling in the details of this imperfect sketch, which will, I trust, be found to be accurate in the main, and which will serve to show how interesting the region is in itself, and in its relation to the rest of the Continent. Of the Upper Amazonas or Marañon region, enough is already known to show its surpassing interest and importance. Between the two, the middle or Solimões region, is an almost perfect blank, in which future explorers will meet with difficulties, even surpassing those presented by the other regions, but will, by well directed efforts, reap results commensurate with the hardihood of the undertaking.

Stated Meeting, January 17, 1879.

Present, 11 members.

Vice-President, Mr. FRALEY, in the Chair.

A letter of acknowledgment was received from the Natural History Society, Emden (100; List).

Letters of envoy were received from the French Minister of Public Instruction; and the Meteorological Office, London, December, 1878.

A letter of thanks for correspondence was received from the Rev. Stephen D. Peet.

A letter respecting exchanges was received from Mr. G. W. Ranck, Curator of the Kentucky Historical Society.

Donations for the Library were received from the Adelaide Observatory; M. P. Volpicelli at Rome; the Geographical Society and Revue Politique at Paris; the Meteorological Office, and Register, and London Nature; the Boston Natural History Society; American Journal of Arts and Sciences; Library Journal in New York; the Franklin Institute, College of Pharmacy, Journal of the Medical Sciences, and Medical News in Philadelphia; the American Journal

of Mathematics at Baltimore; Mr. S. H. Scudder; the Botanical Gazette; Mr. G. W. Ranck; and the Ministerio de Fomento in Mexico.

The American Journal of Mathematics of Baltimore was ordered to be placed on the list of correspondents to receive the Proceedings.

The death of the Rev. E. R. Beadle, D.D., LL.D., in Philadelphia, January 6, 1879, aged 66, was announced by the Secretary; and, on motion, Dr. Robt. E. Rogers, was appointed to read an obituary notice of the deceased.

The death of Mr. Morton McMichael, in Philadelphia, January 6, 1879, aged 71, was announced by Mr. Price; and on motion Mr. Fraley was appointed to read an obituary notice of the deceased.

A letter from Mr. P. W. Sheafer, dated Pottsville, Pa., January 6, 1879, reported the result of tests of the visibility of stars in daylight from various depths of the 1600 feet shaft of the Philadelphia and Reading Railroad Company, near that borough:

POTTSVILLE, Pa., January 6, 1878.

DEAR SIR:—The question of seeing stars from deep wells, &c., being unsettled, I requested Mr. Edward Herbert, an intelligent boss miner, now in charge of the deep shaft of the Philadelphia and Reading Coal and Iron Company, near this borough, to test the question so far as he could find the opportunity to do so in his frequent ascents and descents of the Pottsville shaft, especially, which is some 1600 feet deep.

He reports as follows:

"ST. CLAIR, December 20, 1878.

"Myself and one of the workmen have tried this afternoon at several distances in east shaft, if we could see any stars, but failed to see any. The sky was very clear and atmosphere favorable; the shaft is a down cast, and was entirely free from smoke or steam. I fear we will not be able to solve your problem in the affirmative."

In reply to a further inquiry, as to the depth from which observations were made, he replies as follows:

"ST. CLAIR, January 4, 1879.

"We have tested it at different depths, from 100 feet down to 700 and 800 feet, when the sky has been clear, but have so far failed to see any stars.

After we got down 600 feet the atmosphere is not quite so clear as it is nearer to the surface."

If your society can suggest further tests I will be glad to make them.

I am very respectfully your obedient servant,

P. W. SHEAFER.

To the American Philosophical Society,
Fifth Street, near Chestnut, Phila.

Mr. B. Britton exhibited a small and useful specimen-rock crusher for laboratory use, with mortar and pestle, and described its value in the saving of time and labor.

Mr. Lesley exhibited a proof sheet of Mr. J. F. Carll's colored map of the preglacial water basins of North-western Pennsylvania, prepared for the illustration of his forthcoming third Report of Progress in the Survey of the Oil Regions.

Mr. Marks exhibited and explained a new link-work, which he had invented for the use of his students in describing arcs of epicycloid curves, and which can be made practically useful for plotting the outlines of the teeth of wheels. He also exhibited specimens of other Peaucellier cell forms.

On motion, Mr. Lesley was elected Librarian for the ensuing year.

The Standing Committees for 1879 were then appointed, as follows:

Finance.

Mr. Frederick Fraley,
Mr. E. K. Price,
Mr. Benjamin V. Marsh.

Publication.

Dr. John L. LeConte,
Dr. Daniel M. Brinton,
Dr. McQuillen,
Prof. E. Thompson,
Dr. C. M. Cresson.

Hall.

Gen. Hector Tyndale,
Mr. S. W. Roberts,
Mr. J. Sergeant Price.

Library.

Mr. E. K. Price,
Rev. Dr. Krauth,
Dr. G. H. Horn,
Dr. Kinderdine,
Prof. Houston.

Pending nominations Nos. 871, 872, 873 were read, and Nos. 871 and 873 balloted for. No. 872 was postponed on account of the absence of its nominators.

The reading of the list of members was postponed.

On a scrutiny of the ballot boxes by the presiding officer, the following were declared duly elected members of the Society:

Charles B. Dudley, Ph. D., Altoona, Pa.

Philip H. Law, of Philadelphia.

And the meeting was adjourned.

Stated Meeting, February 7, 1879.

Present, 19 members.

Vice-President, Mr. FRALEY, in the Chair.

Letters accepting membership were received from Dr. Charles Benjamin Dudley, dated Altoona, January 20, 1879; and from Mr. Philip Howard Law, dated Philadelphia, January 20, 1879.

Letters of envoy were received from the Batavian Society of Sciences, Batavia, dated December 15, 1874, August 20,

1875, March, 1876, and October 20, 1877; from the Natural History Society at Chemnitz; and from the Physical Society at Geneva, dated September 15, 1878.

A letter of acknowledgment was received from the Physical Society at Geneva (99, 100).

A letter from Mrs. S. N. Byington, to Dr. Brinton, enclosing a letter from Major J. W. Powell, of Washington, requesting the loan of the manuscript Choctaw grammar, written by the late Rev. Cyrus Byington in 1833, for the purpose of having it published along with Mr. Byington's Choctaw Dictionary, under the editorial care of Prof. O. T. Mason, was read. On motion the Librarian was authorized to loan the manuscript from the Library, for the needful time, on a guarantee of its safe return.

Donations for the Library were received from the Royal Societies of Victoria and New South Wales; the Mining Department of New South Wales; the Academies at St. Petersburg, Berlin, Copenhagen, the Hague, and Brussels; the Natural History Society at Moscow; the Geological Society at Berlin; the Societies at Offenbach, Chemnitz, Geneva and Bordeaux; the Observatory at St. Petersburg; the Geographical Society, Revue Politique, and M. Delesse at Paris; the Royal Astronomical and Meteorological Societies, Meteorological Committee, Lords of Admiralty, and Editors of Nature, London; the Boston Natural History Society; Harvard College; Silliman's Journal; American Journal of Ontology in New York; the Brooklyn Entomological Society; the Pennsylvania Historical Society, Journal of Pharmacy, Editors of Naturalists' Leisure Hour, and Robinson's Epitome of Literature at Philadelphia; the Librarian of Congress, and J. W. Powell, at Washington; Mr. M. C. Reed, Hudson, Ohio; the Botanical Gazette; the Ministerio de Fomento; and the Argentine Scientific Society at Buenos Ayres.

Copies of Proceedings No. 102, and card list of meetings and officers for the year, just published by the Secretaries, were laid on the table.

A letter from the Corresponding Secretary of the Kentucky Historical Society, dated Lexington, Ky., January 20, 1879, was read, and, on motion, the name of that Society was placed on the list of correspondents to receive the Proceedings, from the beginning of the current volume.

A letter respecting exchanges was received from the Michigan Library Association at Coldwater, Mich., dated January 20, 1879.

An obituary notice of the late Robert Frazer, was read by Professor Frazer.

The death of Dr. John B. Biddle at Philadelphia, January 19, 1879, aged 66 years, was announced, and on motion Dr. Henry C. Chapman was appointed to prepare an obituary notice of the deceased.

The death of Judge John Cadwalader, at Philadelphia, January 26, 1879, aged 73 years, was announced by Mr. Fraley, and on motion Mr. McCall was appointed to prepare an obituary notice of the deceased.

A communication, entitled "Preliminary notice of an investigation on *Petrocene*, a product of the destructive distillation of Petroleum, by Samuel P. Sadtler and H. G. McCarter," was read by the Secretary.

A communication respecting some remarkable conjunctions of semi-anthracite and semi-bituminous coal beds in Sullivan county, and certain hygrometric cokes, by Franklin Platt, Assistant on the Geological Survey of Pennsylvania, was read by the Secretary.

A communication, entitled "Some notes upon the collection of coins and medals, now on exhibition at the Pennsylvania Museum and School of Industrial Art, in Memorial Hall, Fairmount Park, Philadelphia, by Henry Phillips, Jr., A. M.," was read by the Secretary.

An essay on the Philosophy of Christianity was read by Prof. P. E. Chase, pursuant to notice given on the card (see page 123 above).

A new combination of Peaucellier cells intended for drawing arcs of large circles and straight lines, by students of the University, was exhibited and explained by Prof. Marks.

Dr. König announced that he proposed to show his new chrometric apparatus at the next meeting of the Society, and give a detailed report of its workings.

The Chairman of the Michaux Legacy Committee, Mr. E. K. Price, read its annual report, as follows:

To the American Philosophical Society:

The Committee on The Michaux Legacy respectfully report:

That the income received from the Government of France, during the last year, was $534.33, of which one-half, $267.16, was paid to the Fairmount Park Commissioners for the purchase of trees; Michaux's Sylva for Park Library, $40; for Dr. Rothrock's Lectures on Botany and Trees in the Park, $280; advertising ditto, $50; Journals of Forestry, three copies, $11.87; planting trees round the University in 1877, $88.80; in 1878, $56.83; printing in 1877, $30.25. The payments last year exceed the income of the year, $168.43; but there is considerable arrears of income unspent.

The Park Commissioners have on hand for the purchase of trees, of Michaux Legacy, $284.98; Cresson Legacy, $379.45.

Dr. J. T. Rothrock delivered a course of lectures on Botany and Trees, in Horticultural Hall, in the Fairmount Park, fourteen in number, to a larger audience, ranging from one hundred to two hundred, than in 1878.

The Committee recommend that Dr. Rothrock should continue his lectures the present year, and that an appropriation out of the income of the Michaux Legacy be made for that purpose, of $280, and $50 for advertising the lectures.

ELI K. PRICE, *Chairman.*

JANUARY 24, 1879.

On motion the recommendation embodied in the report was adopted, as follows:

Resolved, That an appropriation be and is hereby made from the income of the Michaux Legacy, of $280, for a course of fourteen lectures in Fairmount Park, by Dr. J. T. Rothrock, on Botany, Sylviculture and Agriculture; and $50 for advertising said lectures.

Mr. Fraley reported, that he had received and paid over to the Treasurer, the quarterly interest from the Michaux Legacy, due January 1, 1879, amounting to $132.43.

A communication was received from Mr. Geo. W. Morrison, Philadelphia, January 3, 1879, respecting a successful coal dust burning apparatus. On motion this communication was referred to the Board of Officers and Council at their next meeting.

And the meeting was adjourned.

Preliminary Notice of an Investigation on "Petrocene," a product of the Destructive Distillation of Petroleum. By Samuel P. Sadtler and H. G. McCarter.

(*Read before the American Philosophical Society, February 7th,* 1879.)

In the number of *Comptes Rendus* for 16th December last (tome 87, p. 991), which has just come to my notice, appears an article by MM. L. Prunier and R. David, entitled, "sur la nature de certains produits cristallisés, obtenus accessoirement dans le traitement industriel des pétroles de Pennsylvanie."

In this article the authors announce that they have begun an investigation of "Petrocene," a solid residue from petroleum, which they obtained from Dr. H. Tweddle, of Pittsburg, Pennsylvania. They give some general statements as to the several hydrocarbons, the presence of which they consider to have been indicated by the determinations they made of fusing points, boiling points, solubilities, together with crystallizations gotten with picric acid, and with binitroanthracene. Judging in this way, they state that anthracene, phenanthrene, chrysene, chrysogen and other hydrocarbons are present. They give no specific figures of analyses, but say merely that the percentage of carbon varied in their different analyses from 88 to 96 per cent. in 100. After propounding some interesting theories, based upon these indications, they close by promising to communicate the results obtained from a farther study of the subject, if, as they hoped, these should be new.

This same material has been the subject of our investigation for several months past, and we have obtained results which, while not as yet complete, are so far advanced as to be beyond the point of Messrs. Prunier and David's work, as it is stated in their article. We would therefore claim equal right to the field as scientific workers, and shall continue our studies, and hope to push them to an early completion.

The material we have operated on consists of a full set of Dr. Tweddle's preparations, as described by him in the Franklin Institute Journal Vol. 72, p. 204, which was given to one of us some two years ago, by Dr. F. A. Genth, and a bottle of the crude distillate before treatment with petroleum benzine, given to us by Dr. G. F. Barker.

Some weeks of study had indeed been given to these products in the summer of 1877, by one of us in conjunction with Dr. E. F. Smith, of the University of Pennsylvania, which work was interrupted and only resumed, as stated, a few months ago.

The following is a brief and general statement of the ground covered by our work. The conclusions are all subject to revision as the examination of purer products may demand.

We found that the method of breaking up the compound by treatment with solvents did not suffice to give us pure products of constant compositions. We therefore availed ourselves of the method of forming double crystallizations with picric acid from solution in alcohol and benzol. We

obtained what appeared to be three distinct crystallizations here—two of deep red crystals and one of brown plates. These were picked apart as they crystallized together, using a hand lens, and exercising great care, and were then submitted to recrystallizations until quite pure and distinct. On breaking up these picric acid compounds with dilute ammonia, we obtained at least two well-marked and distinctly different hydrocarbons. With regard to the hydrocarbon from the third set of crystals we are still in doubt.

Of the two hydrocarbons, one fuses constant at 280°C., and the other at 178°C. We are not able to identify them certainly with any of the known hydrocarbons.

Of both of these hydrocarbons, quinones have been made, and of one of them the alizarine, acting upon the quinone with strong sulphuric acid with heat, and then fusing the dried residue with solid potassium hydrate. The quinone dissolves in sulphuric acid with a dark purple color, and when the nearly black residue of di-sulphoquinonic acid and potassium hydrate are fused together, a dark yellowish-brown color is obtained. From the solution of this, hydrochloric acid precipitates the alizarine as a dark brown flocculent mass.

Several analyses of the quinone and of the alizarine were made. As I hold the whole subject still open to revision, I will not quote them, but merely say that both the quinone and the alizarine derived from the hydrocarbon, fusing at 280°C., indicate a probable composition C_{16} H_{14}. This would be a dimethyl-anthracene, yet the hydrocarbon does not agree with the dimethyl-anthracene discovered by Van Dorp, and studied by Wachendorf and Zincke.

With this brief mention of the work done, we will defer any further discussion until our results are sufficiently advanced to be presented as a whole. We are now engaged upon the work, and will push it promptly to a completion.

Character of some Sullivan County Coals. By Franklin Platt.

(*Read before the American Philosophical Society, February 7th*, 1879.)

It has already been noted in giving the detailed description of the coal openings in Sullivan county, that the different coals mined presented wide differences in character, and in one or two instances offered some most unusual features.*

These characteristics may be briefly summed thus :†

* See unpublished Report of Progress, Second Geological Survey of Pennsylvania, GG.

† See the analyses made by Mr. A. S. McCreath, Chemist of the Survey at Harrisburg, given below.

1. That the Bernice coal as mined from the Big Bed, called bed B, is a semi-anthracite coal, of the usual chemical composition of anthracites, but differing from them in appearance and fracture.

2. That the coal bed lying sixty feet below the coal bed B is a semi-bituminous coal, of curious structure; holding much water in combination; and not coking.

3. That in a coal bed opened only one and a half miles east of Bernice, the upper bench is semi-bituminous coal, and the lower bench an anthracite, or more nearly semi-anthracite; with only a six inch black slate parting between these two benches; the semi-bituminous coal bench not coking, and holding a very large percentage of water in combination.

4. That the Forksville coals are semi-anthracites of unusual appearance and structure.

5. That the Laporte coal is really bituminous coal, of very curious structure, holding much water in combination.

In order that the main features of the character of these coals may be more forcibly presented, they are grouped together thus :—

1. Bernice, Sullivan County. Run of mine. Bed B.
2. " " " Top bench. "
3. " " " Middle bench. "
4. " " " Lower " "
5. " " " Cannel-like coal in upper bench.
6. " " " Coal 60 feet below Bed B.
7. " " " " " " "
8. Pigeon Creek, 4 miles east of Bernice. Bed B.
9. 1½ miles east of Bernice. Top bench.
10. " " " Lower bench.
11. 3½ miles S. W. of Forksville. Lip. & Mercer mine. Top bench.
12. " " " " " Lower "
13. 1 mile south of Laporte. S. Hall's Coal.

	1	2	3	4	5	6
Water	1.295	1.840	1.800	2.220	1.950	5.815
Volatile Matter	8.100	9.835	9.650	9.405	9.030	15.085
Fixed Carbon	83.344	76.788	82.373	81.267	63.795	62.329
Sulphur	1.031	.647	.622	.618	.583	.474
Ash	6.230	10.890	5.555	6.490	24.640	16.297
	100.000	100.000	100.000	100.000	100.000	100.000
Color of Ash	Gray.	Cream.	Gray.	Cream.	Cream.	Reddish Gray.

	7	8	9	10	11	12	13
Water.....	4.130	2.340	7.930	2.910	.930	.810	6.830
Vol. Matter.	15.270	8.440	21.410	11.780	12.410	13.060	21.930
Fixed Carb.	67.362	80.949	54.099	81.672	75.611	71.679	55.413
Sulphur....	.523	.726	.551	.598	.574	.581	.387
Ash.....	12.715	7.545	16.010	3.040	10.475	13.870	15.440
	100.000	100.000	100.000	100.000	100.000	100.000	100.000
Color of Ash.	Reddish Gray.	Cream.	Cream.	Cream.	Gray.	Gray.	Red.

There is no peculiarity about the chemical composition of the coal from the Bernice Big Bed, or B. The analysis closely resembles that of the Lykens Valley coal; it is burned exactly like any of the other anthracites, and differs from them only in appearance and structure. For all purposes it is classed among the anthracite coals, and is sold for exactly the same purposes.

The coal sixty feet below Bed B introduces at once an interesting inquiry, from the fact that although a semi-bituminous coal it does not coke, and re-absorbs moisture rapidly on cooling after being heated to 225°.

In his report upon the analyses of coals from Ohio, Prof. Wormley has noted the characteristic feature of their re-absorbing moisture when allowed to coal after being heated to 212° F.

In his report on the analyses of the coals of Pennsylvania,* Mr. Andrew S. McCreath, the chemist of the survey, reports that the Pennsylvania coals have no such characteristics; and out of many hundreds of coals analyzed by him only four so far have possessed the power of re-absorbing moisture rapidly after it has been expelled at 225° F.†

Under such circumstances it is desirable to note particularly the appearance, behavior and composition of these peculiar coals.

Three of them are from Sullivan county, and one from the New Red Sandstone in York county.

No. 1. B. Gross coal, from York county, Pennsylvania, on B. Gross farm, on Liverpool road, three-fourths of a mile north of Liverpool, on the Little Conewago creek. Specimen collected by P. Frazer, Jr. The coal is from the Mesozoic rocks.

"The coal has generally a deep black color, with somewhat pitchy appearance. It is very brittle, breaking with *conchoidal fracture.*

Water at 225°.....	4.310
Volatile Hydrocarbons.....	18.482
Fixed Carbon.....	74.358
Sulphur.....	.528
Ash.....	2.322
	100.000

* Report of Progress in the Laboratory of the Survey, M. p. 28, 1875.
† MSS. Report of Progress MM. 1878, now in press.

"The coal yields a bulky ash of a reddish brown color. It has not the slightest tendency to form a coherent coke, and yields volatile matters burning with a non-luminous flame. The water was estimated at 225°, and upon withdrawal of the heat the coal begins to absorb water with great avidity. So that in two hours it has re-absorbed sixty-three per cent. of the amount of water originally present."

Throwing out the water, sulphur and ash, the proportion stands:

Fixed Carbon	80.093
Volatile Hydrocarbons	19.907
	100.000

Volatile Hydrocarbons to Fixed Carbon, as 1 to 4.023.

No. 2. Coal sixty feet below bottom of Bed B, at Bernice, Sullivan county, Pennsylvania.

The coal is for the most part coated with iron oxide and infiltrated silt. It has a dull dead lustre, and is compact and brittle, with very irregular fracture. The coal does not have the slightest tendency to coke and yields gases which burn with a *very* feebly luminous flame. After cooling (water estimation) the coal immediately begins to absorb water and in two hours has re-absorbed about sixty per cent. of the water originally present.

Water	5.815
Volatile Matter	15.085
Fixed Carbon	62.329
Sulphur	.474
Ash	16.297
Color of ash, reddish grey.	
	100.000

Leaving out the accidental impurities, and counting only the ignitible constituents, the proportion stands:

Fixed Carbon	80.514
Volatile Hydrocarbons	19.486
	100.000

Volatile Matters to Fixed Carbon as 1 to 4.132.

It should be noted that this coal specimen was necessarily taken from near the outcrop, which accounts for the oxide of iron coating, the infiltrated silt, and in part for the high percentage of ash.

A second specimen of this same coal (sixty feet below bed B at Bernice) taken from under better cover, was also analyzed by Mr. McCreath.

"The coal does not coke, and the gases burn with a *very feebly* luminous flame. The coal, after being dried, begins to absorb water rapidly, and in two hours has re-absorbed sixty per cent. of the water originally present. This amount is not increased by longer exposure.

Water	4.130
Volatile Matter	15.270
Fixed Carbon	67.362
Sulphur	.523
Ash	12.715
Color of ash, reddish-gray.	
	100.000

On drying at 225° the Coal loses	4.13 %
" " 245° " "	same.
" " 260° " "	4.19 %
" " 340° " "	4.50 %
" " 460° " "	4.69 %
At a dull red heat the Coal loses	12.59 %

But in all these experiments the water re-absorbed is about the same; that is, the coal re-absorbs 2.48 parts of water. Irrespective, therefore, of the amount of water, &c., driven off by heat, the portion re-absorbed is practically constant; and this property is not destroyed, even after all the volatile matter is driven off."

No. 3. Coal from opening one and a half miles east of Bernice, Sullivan county, Pennsylvania. Top bench of coal.

"The coal has a dull dead lustre; it is very soft and crumbling, and has a somewhat shaly appearance with laminated structure. The gases burn with a feebly luminous flame, but the coal does not coke.

Water	7.930
Volatile Matter	21.410
Fixed Carbon	54.099
Sulphur	.551
Ash	16.010
Color of ash, cream.	
	100.000

No. 4. Sullivan county, one mile south of Laporte. From S. Hall's drift.

"The coal has a deep black dull lustre; it is rather friable; contains some slate. It does not show the slightest tendency to form a coherent coke; the volatile matter burns with a *feebly* luminous flame. The coal acts generally in the same way as that from the Bernice lower coal bed.

Water	6.830
Volatile Matter	21.930
Fixed Carbon	55.413
Sulphur	.387
Ash	15.440
Color of ash, red.	
	100.000

Throwing out the sulphur, water and ash, and counting the ignitible constituents only, these coals show the following proportions:

	Coal No. 3.	Coal No. 4.
Fixed Carbon	71.646	71.646
Volatile Hydrocarbons	28.354	28.354
	100.000	100.000

And the proportions of Volatile Matter and Fixed Carbon, are for No. 3, as 1 to 2.527; and for No. 4, as 1 to 2.527.

There are several points touching these coals which are noteworthy:

1. They range in proportion of Volatile Matters to Fixed Carbon from bituminous to semi-bituminous coals; these proportions being 1 to 4.022; 1 to 4.132; 1 to 2.527; 1 to 2.527.

2. They carry an unusual percentage of water; these percentages being 4.310; 5.815; 7.930; 6.830.

3. The gases driven off burn with a non-luminous flame.

4. None of the coals coke.

5. All of the four coals re-absorb in a short time fully 60 % of the water which has been expelled by raising their temperature to 225° F., in this respect differing from all the other Pennsylvania coals hitherto examined.

Notes upon the Collection of Coins and Medals now upon Exhibition at the Pennsylvania Museum and School of Industrial Art, Memorial Hall, Fairmount Park, Philadelphia.

By Henry Phillips, Jr, A. M.

(*Read before the American Philosophical Society, Feb.* 7, 1879.)

"*Quem non moveat clarissimis monumentis testata consignataque vetustas?*"
Spanheim.

The object of this display is to present Art as typified upon coins and medals, from the earliest known period until the present time, so as to show the student the nature and character of the development of æsthetic culture as exhibited by the aid of Numismatic science.

The change and advance presented by the inspection of coins and medals is a vast chain of ever closely joining links. From the very beginning of coinage, from the rudest of all ancient coins, the Persian daric or the tortoise of Ægina, to the majestic medallions of Syracuse, step by step every inch of the onward march of Art may readily be traced. The earliest of all known coins exhibit on the reverse only a shapeless punch mark, are the work of unskilled hands, are defective in type, in shape, in inscription, while the latest (or most modern), present complicated and intricate devices of all kinds and natures.

The present exhibition is composed of the collections of coins and medals belonging respectively to the Library Company of Philadelphia, the American Philosophical Society, and the Numismatic and Antiquarian Society of Philadelphia, under the care of which latter Society the collections have been deposited and arranged by a Committee, of which I am the Chairman. A few private individuals have also contributed to the exhibition.

The display may be divided into three great heads, viz: Coins, medals and tokens (embracing jettons), to the main features of which I shall briefly advert, beginning for convenience sake with the second general subdivision.

The case containing the medals of the Societies is a flat one of five trays on the western wall of the main hall of the building to the right of the entrance of the India room. They are of gold, silver, copper, bronze, brass and lead. The first series to be noticed is one consisting of thirty-one bronze medals of large sizes, commemorating victories and notable events in the history of the empire of Russia, from the time of Peter the Great to that of Catharine the second. They are all of very high relief, and bear for the most part on their obverse the nude bust of that Empress, exhibiting her as a young woman, and as time passes on showing the alterations it has caused in her appearance.

There are silver medals given by Kings George First and Second to the North American Indians, usually worn by the sachems as gorgets, and interred with them at their decease.

The one which bears the head of King George the Second is stated, in Vaux's life of Anthony Benezet, to have been cut in America, and is especially worthy of notice on that account, as having been the first medal ever made in this country. It is cut in very bold style, although the reverse is decidedly stiff of execution. The obverse bears the bust of King George the Second, with his titles, the reverse a Quaker seated on the ground is receiving from (or handing to) an Indian the calumet of peace; around is the inscription, "Let us look to the most high who blessed our fathers with peace."

Another silver gorget bears on the obverse an antique view of the city of Montreal, on the reverse engraved the word "Mohigrans," and in script the name *Tangran*, being probably the appellation of the chieftain to whom it had been presented.

The Indian medal of George the First bears on the reverse an Indian, armed with a bow and arrow, taking aim at a stag.

A series of well executed medals represents scenes in the lives of Louis XV., Louis XVI., Marie Antoinette, Lord Howe, Lord Cornwallis, Suwarrow, and others. There are fine medals of Rousseau, Lafayette, Liebnitz, Gauss, Thiersch, R. M. Patterson, David Rittenhouse, Berzelius, Charles XII., of Sweden, Louis XVIII., Napoleon (commemorating the introduction of vaccination), Napoleon and Josephine (accolated), Marquis of Granby, Earl Kildare, one commemorating the millenial anniversary of the Kingdoms of Sweden and Norway, one of King Augustus of Poland, and other celebrated persons and events.

A series represents the "Medallic History of the American Revolution," on which appear Franklin and Washington with various symbolical reverses. There are medals of Pitt, of Penn, and quite a number of Washington, embracing the "Manly," the "Sansom," the "Eccleston," the "C. C. A. U. S.," "He is in glory," &c., &c., &c.; medals commemorative of the peace of 1814, and that of 1783; one given to Defleury upon the capture of Stony Point, a fine gilt medallion of the Earl of Essex, cut by the celebrated Simon, in the days of the Commonwealth.

There is an interesting series of medalets in copper ranging in date from 1584 to 1620, representing various occurrences in the wars between King Philip the Second of Spain, and the United Provinces. A quaint silver medalet of the Sixteenth Century has on the obverse, David playing upon the harp before Saul, and on the reverse, David slaying Goliath. A medal of Sir Humphrey Davy and one of Matthew Boulton are especially noticeable for the boldness and finish of their execution, as well as one cut by Key (the medallist of the United States Mint) for Columbia College, New York city, bearing on the obverse a magnificent female head with the inscription "Light, Liberty, Law." There is also a medal of Hon. Eli K. Price, President of the Numismatic and Antiquarian Society of Philadelphia, issued on January 1, 1879, in commemoration of the Twenty-first anniversary of the foundation of that Society (also cut by Mr. Key).

An especial attention should be given to a remarkably complete series of Papal medals, seven hundred and sixty-four in number, starting from Pope Martin V. (1415), and ending with Pius IX. These medals were deposited by Thomas Hockley, Esq., of Philadelphia, and are in a case by themselves in the main hall. They are of fine execution, and of great historic interest. Among them may be found two engraved by BENEVENUTO CELLINI, one of Clement VIII. (1523–1534), (No. 47), representing Joseph making himself known to his brethren (being in allusion to the Pope's fraternal feelings toward the Florentines, his compatriots, despite their slight gratitude towards him); another (No. 52), of Paul III. (1534–1549), exhibiting a bust of that Pope with Ganymede, and an eagle on the reverse.

Several of the medals refer to the opening and the closing of the *Porta Santa*.

Various medals refer to the wars waged against the Turks by the Spaniards and the Venetians. No. 96 represents the victory of Lepanto in 1571; No. 89 refers to the conspiracy and punishment of Cardinal Caraffa and his accomplices; No. 110 (Gregory XIII.), (1572–1575), commemorates the massacre of Saint Bartholomew; No. 130 the Reformation of the Calendar in 1582; No. 153 (Gregory XIV.), exhibits the Pope giving to his nephew Hercules Sfondrati the banner of the Holy Church, upon his departure to fight against the French Protestants in 1591; No. 181 (Gregory XV., 1621–1622), represents the canonization in 1622 of the Saints Ignatius Loyola, Francis Xavier, Philip de Neri, Isidora and Theresa; No. 243 (Innocent X.), the Holy Ghost, being in reference to the condemnation of the doctrines of the Jansenists; No. 294 (Alexander VII.), represents the Castle of St.

Angelo adorned with statues; No. 313 (Clement X., 1670–1676), commemorates the victory of John Sobieski, King of Poland, over the Turks, and exhibits him offering to the Pope the flags captured from the conquered enemy; No. 338 (Innocent XI., 1676–1689), the condemnation of Molinos; No. 342 refers to the alliance against the Turks formed by Innocent XI., the Emperor Leopold, John III., King of Poland, and the Doge of Venice in 1684; No. 355 (Alexander VIII., 1689–1691), the capture of the Morea by the Venetians from the Turks (we may note that the Parthenon was destroyed by Venetian bombshells in this encounter after surviving the hand of time for centuries after centuries); No. 381 (Clement XI., 1700–1721), represents the mission of Cardinal de Tournon to China; No. 390, the machine by which the obelisk of the Plaza del Monte Cettorio at Rome was elevated; No. 440 the arch of Constantine at Rome; No. 492 (Clement XIII.), the city and fortress of Civita Vecchia; No. 559 (Pius VII., 1800–1823), the bringing back of the Laocoön from Paris to Rome; No. 561, angel delivering St. Peter from prison; No. 572, the introduction of vaccination into the States of the Church; No. 577 (Leo XII., 1823–1829), Saint Peter announcing the opening of the Jubilee; No. 679 (Pius IX.), Rome triumphant wrapped in the Pontifical flag; No. 680, medal for those who exhibited their fidelity to the Pope; No. 686, medal for the Pontifical volunteers; No. 700 and No. 702 relate to the visitation of the cholera in 1854; No. 706, the opening of the railway from Rome to Frascati; No. 728, Daniel in the lion's den, refers to the Piedmontese invasion of 1861; No. 744 and 745 commemorate the eighteen hundredth anniversary of the martyrdom of Saint Peter and Saint Paul; No. 754, the Roman exposition of 1870; also, eight special medals of Pius IX., commemoratingthe œcumenical council, and the twenty-sixth and twenty-seventh years of the papacy; in all seven hundred and sixty-four medals.

This magnificent series is replete with interest historical, architectural, artistic and numismatic. Many of the public works and buildings of Rome are figured both in their former and present conditions; churches, basilicas, façades, palaces, aqueducts, armorial bearings, sepulchres, canonizations, victories, are all represented in this (very rarely) complete collection. The workmanship is of the highest order of merit, and the medals are in the finest possible condition. The example of Mr. Hockley is one worthy of imitation by our public spirited citizens, who in so many instances require but the knowledge of a need to be brought to their notice.

According to Henin, there are six grand chronological epochs of coinage, all of which may with great certainty be known from the indications afforded us by the metals, the legends, the form of letters, methods of fabrication and style of art.

First. From the first invention of coinage to the time of Alexander the First, King of Macedonia, *i. e.* from about the seventh century B. C. to the year 454 B. C. This was the rudest epoch of the art; the metal was mainly silver, some little gold, and no copper. The form of the coins was globular and irregular, bearing on the reverse the rude punch mark (*creux*

carrè), and sometimes the incused figure of the obverse. The legends were of the simplest character, being only the names of cities or magistrates, sometimes from left to right, sometimes in the contrary direction, and sometimes returning in the manner known as *Boustrephodon*.

The artists who produced these coins did so without models or the accessories of a later age, and arrived, nature led, at a style both sublime and true. A remarkable difference exists between ancient and modern coins, the former being of extremely bold execution and high relief, while the latter are comparatively flat and low, the *haut relief* preserving the types of the coins longer after entering into circulation.

Second. From the death of Alexander the First to the time of Philip the Second, the father of Alexander the Great, B. C. 359.

It was during this period that the arts attained a very high perfection in Greece, and it has been believed that the fine engraving upon coins was executed by the hands of artists skilled in the working of precious stones. Copper coinage, but in small quantities, now began to be used as currency, being first struck (in Macedonia), by Amyntas Second (307 B. C.), and is referred to in a passage in "The Frogs" of Aristophanes as having been but lately introduced into Athens. Simplicity was still preserved in art, leading to the grandest results.

Third. From the accession of Philip the Second to the subversion of the Roman Empire by Augustus Cæsar (B. C. 30).

Now the arts had reached their apogee, and coin after coin may be cited as *chef d'œuvres* of the skill of the ancients. The inscriptions became more complex, embracing titles of magistrates, divinities, dates, monograms and similar indications. Regularity and exactness are now more characteristic of the coinage, and the art of striking reached a greater degree of precision than ever before. The mechanical means employed were still simple, and remained so for many centuries; the remarkable results obtained from such slender appliances are the more noteworthy from that fact.

Fourth. From Augustus to Hadrian (A. D. 117). The decadence of art and the diminution of the importance and prerogatives of the Grecian nations began now more sensibly to make themselves perceptible. The moneys struck by independent cities lessened in number and excellence, and many nations lost their former right of coinage. Copper began to usurp the place of other metals, being issued in much larger quantities than formerly, and the art of coinage commenced to exhibit symptoms of decay, although faint suggestions of former grandeur occasionally occur.

Fifth. From Hadrian to Gallienus (A. D. 260). Great and rapid was the decline of art in this period, full of troubles of all kinds for the empire, surrounded by barbarians, and torn by intestine dissensions.

Sixth. From Gallienus to the fall of the Eastern Empire (1453). The arts fell completely into barbarism during this long interval. There is but little to attract in the coinage of either the Eastern or Western Empires, and much to repel. The coins became harsh and hard, and finally lost all traces of any pretensions to the name of art. The imperial Greek, the Colonial

and the Autonomous series had long disappeared, the only circulating medium was the Roman coinage, now became barbarous in the extreme, and small in number.*

The exhibition of coins is in a standing case near the centre of the main room. Naturally it starts with the earliest of all known coinage (about 700 B. C.), the *Persian Daric*, of which an example in silver is shown. It bears on the obverse a kneeling archer, while the reverse is simply the rude punch mark, such as is found only on the most ancient coinages. It is to these coins that allusion is made in the story told of Agesilaus having been overcome by thirty thousand archers, meaning that that amount of Persian daric had been expended to procure his defeat.

Two large silver coins of Athens (known as Tetradrachms from their size), one about 400 B. C., the other perhaps two hundred years later, exhibit the modification of type and change of workmanship. On the reverse, the rude archaic owl in bold relief with great staring eyes has given place to a less aggressive bird; the simple inscription $A\Theta H$ has received in addition the names of the moneyers; the diota and olive branch lend additional significance to the bird of wisdom. On the obverse, the thoroughly Egyptian type of face displayed on the helmeted head of Pallas has been metamorphosed into the now generally received conventional type of Greek art. In antiquity these coins were known as *maidens*, referring to the spinsterhood of the goddess represented upon them, and also as "owls," from the figure upon their reverse. In one of the Greek dramas a miser is spoken of as having myriads of owls roosting beneath his roof, meaning that he had large quantities of these coins concealed in his house.

A fine Cistophorus of Apamea presenting the sacred *cista* of Dionysos enveloped by serpents is worthy of particular notice. The cistophori are tetradrachms, which bear as their generic type a wreath and berries of ivy, surrounding a chest whence issue serpents, being in reference to those carried in procession by the Bacchantes in their orgies, especially in Asia Minor, where the snake was revered, and considered as an emblem and tutelary god.

All the cistophori which exist are tetradrachms of silver, uniform in weight and fineness, and were struck by some one of the following cities, viz: Apamea in Phrygia, Ephesus in Doria, Laodicea in Phrygia, Pergamos in Mysia, Sardes and Tralles in Ionia.

They were of such exceeding purity and fineness that the Romans would receive no other coins in payment of the tribute moneys exacted from the cities of Asia Minor; for this purpose they were coined in great abundance, and in ancient days were very plentiful, although at the present time they have become of quite rare occurrence.

M. Acilius in his triumph from Corinth, bore in procession 288,000 cistophori, Cn. Manlius Vulso, 250,000; L. Amilius Regillus, after a victory over the Antioch fleet, 131,000; Scipio Asiatica, 331,070. It is probable that these pieces, upon their arrival at Rome, by reason of their superior fineness

* Henin, Numismatique Ancienne, *passim*.

and quality, were at once recoined; a fact which would account for their present scarcity*

Cista mystica existed in the sacred rites of the Panathenæa, of Diana, Eleusinia, Ceres, Theogamia Proserpine, and the Dionysia or orgies of Bacchus.

Upon the tetradrachms of Eleusis, serpents were the symbols surrounding or issuing from the cista, either as representing divine attributes, or the fable of Erichthon. On others, surrounding the chest were various emblems, such as combs, the pudenda muliebre, food, drink or fruits, and it was looked upon as a heinous sacrilege to divulge the meaning of these recondite objects.

A type also exists in which Bacchus, in womanly garb, is figured seated upon the cista mystica, holding in his right hand a thyrsus, below which are two serpents knotted and twined together. Chests, whence serpents are out-issuing, are found on the coins of Anchialis in Thrace, Sardis Nikaea, Pergamos, Perinthos and Teos.

A quinarius of Augustus Cæsar exists, on which is engraved the cista between two serpents, and over which hovers a victory with the inscription ASIA RECEPTA.

A fine tetradrachm of Bœotia exhibits on the obverse the familiar Bœotian shield, and on the reverse, a cippus. The type of the buckler took its origin from the renown acquired by the workmen of this nation from their skill in this manufacture. In Homer we find mention made that the shield of Ajax was made at Hyle in Bœotia. Some authors have imagined it to be a perverted type of the Egyptian scarabæus, while the cippus represents the purifications and lustrations used in the worship of Bacchus. This latter opinion seems to be further borne out by the fact that the head of the Indian Bacchus is also frequently found upon the coins of this country.

A didrachm (*i. e.* a piece of two drachmas) of Tarentum, exhibits Taras, the fabled founder of the city (a son of Neptune), riding upon a dolphin. The coinage of Tarentum is numerous, presenting many different types, is always well executed, and exhibits a high degree of culture and art.

A didrachm of Argos shows on the obverse a running wolf, while the reverse has solely the letter "A" within the rude punch mark characteristic of the ancient period of its coinage.

On Messana we find the type to be a running hare, on the reverse a figure in a chariot, of which the execution while bold is rather rude. Messana is fabled to have been founded about 1600 B. C. under the name of Zancle, an appellation which was changed about 594 B. C. Destroyed by the Carthaginians in 396 B. C., it was subsequently rebuilt, and in 282

*NOTE.—Livius Dec. X. L. VII.

Alex. Xan: Panelius de Cistophoris. Lugdun, 1734.

Rasche Lexicon Rei Numariæ.

B. C., after having been captured by the Mamertines it received the name of Mamertina.

Rhodus presents the radiated head of Apollo, and on the reverse a rose, being a so-called speaking type. Spanheim,* however, considers this flower not to be a rose, but the Punic apple (*Balaustus*), citing Isaac Vossius as his authority. This plant was used for dying vestments, and is still known to the modern Arabs. According to Theophrastus, its flower resembled that of the rose, and Clement, of Alexandria, states that in the Thesmophoric rites women were not allowed to make use of it.

Upon the coins of Massilia (now Marseilles), we find a walking lion of fine workmanship; on Syracuse, the head of Proserpine in an incuse surrounded by dolphins, on the reverse a figure in a chariot. In the coins and medallions of Syracuse, ancient art reached its highest pinnacle of perfection; they are beautiful of design, grand and graceful of execution, bold of relief.

There are coins of Alexander the Great of Macedon, and a fine Tetradrachm of his father, King Philip the Second, bears upon the obverse a powerful head of Zeus, on the reverse, a horseman wearing the hat peculiar to Macedonia, surrounded by the inscription ΦΙΛΙΠΠΟΥ. The celebrity of the Macedonian and Thracian horse probably led to its adoption as a national type.

An extremely rare and fine silver coin of Juba the Second, King of Numidia, is noteworthy on account of its historical interest as well for its artistic merits. It bears on the obverse the head of that monarch with curly hair and a conical cap; on the reverse a temple.

A didrachm of Velia, in Lucania, presents a fine head of Apollo, and on the reverse a lion destroying a stag.

Tetradrachms of Antiochus, and one of Lysimachus, of magnificent workmanship and grand design, in the finest possible preservation, must especially claim the attention of the student as examples of Grecian art in its finest stage of development.

These coins are two thousand years old, and are almost as fresh as the day they left the die, while their entire genuineness and authenticity is beyond the faintest cavil or suspicion.

Space will not permit that we should enter into a full description of all the beautiful and artistic objects which this exhibition comprises, and we must content ourselves with a rapid survey of the most salient features of this display.

There are also a number of fine copies of rare Grecian coins, and an especially noticeable selection of forged Roman first bronzes, executed by the celebrated Paduaan forgers, Jean Cavino and Alessandro Bassiano, in the sixteenth century. The work of these artists has long been sought after on account of its exceeding great merits of design and execution, worthy to rank with the best workmen of antiquity. Many of these pieces are pure inventions of the forgers' brains, no originals ever having existed, while

* De usu &c. numorum p. 374, et seq.

others are well engraved counterfeits. These were originally sold only as copies of antiques, but their makers were subsequently induced to dispose of them as genuine.

The boldness of design and power displayed in the treatment of their subjects is of a very high degree of excellence.

The coinage of the ancient Greeks was very rarely (if ever) of a circular form, owing to the imperfection of the processes employed. They did not possess the knowledge of the collar by which in modern times accuracy in striking is ensured, and the result was in many instances that the coin contains only a portion of the device or inscription, the rest having failed to reach the planchet, as there was no means of holding it firmly in place to receive the stroke of the hammer.

The types that occur on the coinage of the ancients are manifold. The bull, the emblem of strength and force, is often found joined to a human head, as on the coins of Gelas, where it signifies human intellect and physical perfection. The bull occurs also in combat with the lion symbolizing the conflict of the fire element (or the sun), and that of water (*i. e.* the bull); this type is often found upon the Persian coinage. The serpent also frequently represents the ocean.

The earliest kings who placed their portraits upon coins, did so under the garb or disguise of gods and heroes; thus Alexander the Great appears as Herakles and Jupiter Ammon; Lysimachus, as the Horned Bacchus, and other examples will readily be found.

Their portraits, professedly as that of human beings, appeared on no coin till after the death of Alexander the Great, and even then the change took place with great caution and circumspection.

The leading characteristic of the coinage of the ancient Greeks, and as such it is to be found even upon their very earliest known specimens, is sublimity.* This arises from the simplicity of thought and object with which these early coins were designed and executed, and is the cause of the calmness and the repose of the Grecian art. Even the most archaic types possess this property, although in the transition stage from the rude to the excellent. Neatness and stiffness constitute archaism in art, and the condition of the early Greek mind has been compared by Humphreys very justly to the quaint productions of the masters of the fifteenth century.

Grecian art attained its highest perfection during the third period to which I have already alluded, viz: From the accession of Philip the Second of Macedon to the final subversion of the Roman liberty under Augustus Cæsar. In the cities of Magna Grecia, it reached a most extraordinary degree of culture, regardless of their not far distant neighbor, the robber city, founded by outlaws, and living by rapine, that city, whose ambition still comprised within petty limits, had not yet broken its bounds to fly its conquering eagles above a prostrate world.

Rome now claims our attention. Its series is composed of gold, silver and bronze. The oldest silver pieces, denarii, are of the value of ten asses

*Humphreys.

(the letter X which so occurs upon them is the exponent of their value), and bear the galeated head of Minerva on one side, on the other the Dioscuri; sometimes on the reverse a biga or quadriga.

Later the names of illustrious families appear on them, whence these have often been termed family coins, as for example, the name of COCLES on those of the Horatian gens; sometimes emblems or types commemorating heroic exploits or punning upon their own names, as upon the coins of Publicius Malleolus we find a hammer, of Valerius Asciculus, a pickaxe; of Aquilius Florus, a flower; of Lucretius Trio, the seven stars (Septemtriones), &c.

Upon certain of these coins we find deities appropriated, thus *Juno Sospita* on the families Cornuficia, Mettia, Pappia, Roscia; *Ceres* on Claudia and Vibia; *Libertas* crowned with laurel and veiled on Sestia; crowned with olive branches on Licinia; crowned with laurel on Junia; veiled on Æmilia and Calpurnia. Sometimes Libertas appears as a female standing, holding in her hand a liberty cap, in her left the rudis, or rod, whose touch manumitted slaves. Upon the early copper coinage of the United States we find the head of liberty accompanied by the cap and rod, being in allusion to this Roman custom.

Among the family coins in the exhibition, there is one of the gens *Cornelia* bearing on the obverse an archaic head of Minerva galeated, and the inscription SULA; one of the gens *Hostilia*, obverse a diademed head of Venus, reverse, a victory walking, holding caduceus and palm branch, inscription SASERN. L. HOSTILIUS. Saserna was the cognomen of this noble family which deduced its descent from King Tullus Hostilius. Some of their denarii bear the head of Pallor or Pavor, to whom that monarch vowed a temple upon the occasion of his battle with the Veiéntes.

A denarius of Julius Cæsar bears an elephant trampling upon a snake which is rearing its head; reverse, the simpulum, adspergillum, apex and securis victimaria, emblems of his pontificate. The elephant is said to refer to his victories over Juba, King of Numidia, and the subjugation of Africa of which it was the symbol. Other authorities consider it as a speaking type, asserting that the word Cæsar, in the Punic tongue, signified an elephant. One author has informed us that these sacred emblems (whose use and meaning is so well known to us) were nothing but the weapons with which the Romans were wont to fight against elephants in time of battle.

Upon a denarius of the gens Scribonia we find on the obverse a female head with the inscription LIBO. BON. EVENT.; reverse a puteal (or well stone) in the form of an altar with the inscription PUTEAL above, SCRIBONIA in the exergue. This is a very interesting coin referring to the puteal in the Comitium built on the spot where the events of the story of King Tarquin and the augur occurred, and where in later days the knife and the whetstone were found buried. Here were oaths taken as an especially sacred place.

Many such puteals abound in Pompeii, in the form of circular altars,

richly decorated with sculptures. The one which this coin presents has on each side a lyre suspended with a festoon in the middle and a hammer at bottom. It would seem that L. Scribonius Libo renewed this puteal, whence it obtained his name. It is twice referred to in Horace (Epist. Lib. I. 19. 8., Sat. Lib. II. 6. 34).

In 1812 an altar was found at Veii, in every respect corresponding with this representation, and it is likely that the puteal Libonis served as a model for imitation in other places.

After the decline of Roman liberty the emperors coined gold and silver, but the bronze remained the prerogative of the Senate. Upon the reverse of the imperial denarii occur many interesting types such as Pax, Providentia, Pietas, Fecunditas, Æquitas, Concordia, Tranquillitas, Constantia, Pudicitia, Decursio, Adlocutio, Fides, Spes, Victoria, Fortuna, and a multitude of others. Upon the decease of an emperor, it was the custom to deify him, and to issue coins commemorating the event; they usually bear on the reverse the word CONSECRATIO, and an eagle soaring to heaven, or a chariot drawn by four elephants, or a Phœnix, the head on the obverse being surrounded by rays. When it was a female who received this honor, as in the case of one of the imperial family, the reverse bore a peacock, or a chariot drawn by peacocks, or a carpentum drawn by mules.

The servile adulation which had been their portion in life was not ended even in death.

The very earliest of the Roman coinage was of copper (or bronze), and was issued by Servius Tullius, about the sixth century before Christ. The *As* was the primitive monetary unit of Rome, and although from time to time reduced in weight retained its legal value always unchanged. The coinage of silver, the denarius, quinarius, and the sestertius began about 269 B. C.; gold was first minted about 206 B. C.

One coin alone has preserved to us the monetary implements of the ancients; a denarius of the gens Carisia bears on the reverse the pincers, hammer, anvil and bonnet of Vulcan.

When the first Triumvirs placed their own effigies upon the coins, they gave a great shock to the ancient habits and superstitions of the Roman people by displacing the old traditionary types of gods and goddesses. Pompey and Cæsar were the first to set the example, which was followed by their relatives and their successors in authority, although by some authors it is held that the head of Pompey was not placed upon coins until after his death, and that it was then done by his sons.

Among the imperial Roman series are many fine and rare coins, starting from Julius Cæsar and coming well down to the later days of the Byzantine empire. There are pieces of Augustus, Agrippa, Mark Antony, Antoninus Pius, Ælius Cæsar, Caracalla and Geta, Domitian, Claudius, Caligula, Elagabalus, Gallienius, Herennus Etruscus, Hadrian, Julian the Second, Maximinius, Marcus Aurelius, Philippus, Pertinax, Titus, Trajan, Vespasianus, and many others. They all bear the image of the emperor on the obverse, and on the reverse in many instances commemorate important

events. They are in no way remarkable for the art displayed upon their coinage, and maintain their chief interest from their historical associations, while their claims to be regarded as exhibiting a graceful execution are very slight when we compare them with the *chef d'œuvres* of the Grecian artists. The arts never flourished in Rome as they did in Greece, they were never indigenous to the soil that bore a band of rugged heroes.

The coinage of the Roman nation, from its earliest inception down to the capture of Constantinople by the Turks, presents to us a lengthy and uninterrupted chain for two thousand years. Upon the series are preserved to us the portraits of the monarchs, their wives and families, relations and generals; it forms a connecting link between the misty, shadowy realm of the forever past, and the living, breathing, moving present of to-day.

Upon the coinage are found their wars and conquests and expeditions, imperial voyages to distant portions of the empire, valuable historical facts and epochs. We shall take occasion later to more fully advert to these interesting records.

Coins of the Sassanidæ, the rulers of the second Persian empire, from about 226 A. D. to 651 A. D. are curious and interesting. They are thin flat silver coins, bearing on the obverse a bust of the monarch wearing a peculiar head dress, on the reverse a fire altar stands between two figures dressed in the old Persian garb (representing respectively the genii of good and evil), and an inscription in Arian characters is at the side. These coins are of uncouth and barbarous design and workmanship, and represent a period of decadence in art before the Mohammedan conquest had prohibited the representation of the human figure as idolatrous.

The art of coinage, as carried into the East by Alexander the Great, remained in Bactria and India for many centuries, where money was long coined with inscriptions in the Greek languages, the coins of the Arsacidæ in Armenia, and of the Sassanidæ in Persia, bringing the mintages of Central Asia down to a comparatively recent period.

We now come to the coinage of Great Britain, as being a good connecting link between the Roman and the modern eras of coinage. A very heavy and uncouth gold British coin of remote antiquity, perhaps of a period even before the days of Cæsar, marks the beginning. Then in regular order come the rude coinages of the various early monarchs (too familiar to require description here), pennies, groats, &c., &c., broad gold pieces of James I., Charles I., and the Commonwealth of England; a very fine crown of Queen Elizabeth; gold "touch pieces," given by Kings Charles the Second and James the Second, to those unfortunate beings whom, in conformity with the superstitions of the times, they "touched" to cure the King's evil; a fine Gothic pattern crown of Queen Victoria, but never adopted for the national coinage.

Coins of Philip and Mary, bearing both their heads. These were current until a comparatively recent date, and were referred to in Hudibras:

> "* * * * * cooing and billing,
> Like Philip and Mary upon a shilling."

Scotland is represented by coins of John Baliol and Alexander the Third, and a fine dollar, bearing the name of Queen Mary and her husband, the ill-fated Darnley. Upon the reverse of this coin is a yew tree, popularly supposed to be the one which grew in the court yard of Darnley's residence at Cruikston, from which circumstance this coin is known as the "Cruikston dollar."

There are also a number of coins of the English sovereigns struck for Scotland and Ireland, and various siege pieces of Charles the First, who never in all his extremities resorted to the expedient of a debased coinage.

Germany, rich in silver mines, exhibits a number of fine crowns of different emperors, dukes, bishops, &c., &c. ; and a coin of Vladislaus of Poland (a noble kingdom, for centuries the bulwark of Christendom against the Turk, in the end despoiled and devoured by the very monarchies which its valor had preserved). These pieces range from 1586 to 1689. There are also many silver pieces of the various countries, comprising the Netherlands, such as Gueldres, Zeeland, Campen, &c., &c.

A full line of Spanish and Portuguese coins carries us from the sixteenth century to the present time, among which, is a silver dollar of Philip the Second of Spain, on which among his titles appears that of King of England.

France is represented from Henry the Fourth, including a number of silver ecus of various monarchs. On those of Louis the Fourteenth, we can trace the progress of his years, his coins exhibiting him in various stages from youth to old age. Louis XV. is shown as a very handsome young man. There are also coins of Louis XVI., Napoleon, Louis XVIII., Louis Phillippe, Charles X., the Republic of 1848, Napoleon Third, and the present Republic.

Russia shows specimens of the platinum coinage, which, after a short trial, was abandoned as an unsuccessful experiment, and which is very rare.

The coinage of the Orient is largely represented, including a full set of the rare and curious "bullet money," from Siam, formed by bringing together the ends of oval pieces of silver, and on each piece is stamped a minute mark showing its value. Each "bullet" is perfectly symmetrical and its weight is very accurately and carefully proportioned to that of the other pieces. They are eight in number, and are named Pie, Sungpee, Fung, Salung, Song Salung, Tical (or Bat) Songbat, Sibat.

There are some curiously stamped coins from Cochin China, long and narrow in shape.

Japan presents a full set of gold, silver and copper coinage, both ancient and modern, the liberal gift of Lieutenant Paul, U. S. N., to the Numismatic and Antiquarian Society of Philadelphia, upon his return from the Orient.

There are coins of the great Orkan, and also a complete series of thirty-three Ottoman monarchs, the successors of Mahomet, very rare but barbarous in art and uninteresting, save from historical association.

There are specimens of the coinage of the Caliphs of Bagdad, and of the Moorish rulers of Spain.

There are also some of the "chopped" money, current in China, where the custom exists of mercantile houses placing their "chop" (or guarantee firm name) upon all the silver money that passes through their hands. The effect of this is very soon to render a coin utterly unrecognizable through the multiplicity of "chops" that it had received.

Scandinavia presents nothing remarkable, except the copper *dalers*, issued in the reign of Charles XII., when his insatiate thirst for glory had almost reduced his kingdom to beggary. To obtain the necessary revenues for carrying on his mad career he issued small copper pieces which were to be a legal tender for a dollar. The experiment failed, after working the usual amount of hardships, and its originator, Baron Goertz, paid with his life the penalty of its ill-success.*

In America we find an uncirculated cent of 1793, a beautiful head with flowing hair, an object far more tasteful than the last design with which the authorities of the United States mint have favored us. The very rare silver piece coined by Louis XIV., for circulation in the Franco-American colonies, known as the *Gloriam regni*, exists here in fine condition, as also the Rosa Americana half penny, coined for circulation in British North America, in the reign of King George the First; Georgius Triumpho, Immunis Columbia, Bar Cent, Nova Constellatio, Talbot Allum and Lee (of New York) cent 1794, the Higley copper, coined in Connecticut in 1737, Nova Cæsarea, Vermont, Virginia, Nova Constellatio, Connecticut and Massachusetts coppers, Massachusetts shilling and three pence of 1652 (of which former coin it is narrated that the daughter of the mint master was given her weight as a dowry, she standing in one scale while the money was poured into the other), the sixpence issued in 1783, by I. Chalmers, a jeweller at Annapolis, a very fine Washington cent 1791, large eagle, a number of fine proof-sets and coins of the United States Mint, including the pattern dollar of 1836, the set of pattern cents of 1858, the pattern cents of 1850, 1855 and 1854, the set of pattern half dollars of 1868.

Among the patterns is a *goloid metric* dollar, a composition, the invention of William Wheeler Hubbell, Esq., which was proposed as being especially adapted for the coinage of the standard dollar. It contains gold, silver and copper in fixed proportions, but presents the feeling and appearance of a very light silver coin. Of these patterns there were not more than twenty-five struck and it is of the greatest rarity.

There is the general and customary assortment of the coins usually incident to the American series, a series which contains very little either of beauty or of interest, so that in the present instance where our aim was mainly to exhibit *Art* no attempt has been made towards a display of mere numismatic rarities.

*The names of this series are as follows:

Crown . . . . . 1715.	Saturn . .	1718.	Flink och fardig	1719.
Pallas . . . . . 1716.	Jupiter . .		Hopel	
Publica fides . . . . . 1717.	Mars . . .		Gœrtz's Head.	
	Mercury . .			
	Phœbus . .			

The object in hand is to show Art in its origin, growth and progress; Art as a hand-maid for the illustration of mythology and the elucidation of history; Art as an interpreter of the classics, where many obscure passages find upon coins their only true solution. Treatise after treatise has been written to show the advantage to be derived from the study of ancient coinages. Agostino, Goltz, Strada, Eckhel, Spanheim, and a myriad of others have contributed their stores of knowledge to the general fund.

Coins throw light upon the history of nations, their forms of government, the political condition of their citizens; they indicate the classification of their inhabitants; they serve to fix the successions of monarchs, the events of their reigns, and the dates of eras. They have preserved to us the names of a multitude of civic magistrates and rulers, their offices and functions. They have presented to us the images of sovereigns and great personages of history, the heroes of antiquity, poets, painters, philosophers, and sages, gods, goddesses, demigods, legislators and women of fame. They have added largely to our geographical knowledge of the ancient world, exhibiting rivers and fountains, seas and mountains, rocks and other characteristics of places. Many cities have borne different names at various times and coins alone have authenticated their proper attribution. Coins bear frequently types which relate to the religions of the ancient world, both as representing persons, ideas, creeds, shrines, temples, altars and places of worship, sacrifices, utensils and sacred objects. The holy stone to whose worship Elagabalus was consecrated, Diana of the Ephesians, and many similar devices exist on coins.

Many customs are found on coins, such as *congiaries, games, allocutions*, &c., and ornaments and forms of dress are also thus preserved to our times.

Architecture has also been enriched by the edifices, bridges, arches, columns, monuments and similar objects which historians have not fully described, as being too familiar a subject or else have totally passed over, not being then in existence.

When we consider the vast extent of the riches and possessions of so many of the potentates and states of antiquity, the enormous quantity of ancient coins which have survived to our times should not surprise us. The antique earth was a world of commerce, as is our modern globe of to-day; for the requirements of a commerce, which we know was an extensive one, large quantities of circulating medium were necessary, and the great mines of the archaic days furnished immense supplies of the precious metals. The Syracusans, the Athenians, Philip the Second of Macedon, Alexander Magnus, the Ptolemies of Egypt, and lastly the Romans, all issued great quantities of coined money during long centuries; they were all wealthy and prosperous. In the Royal collection at Paris, probably the finest in the world, there are representative coins of sixty-five thousand different nations, cities and princes; the whole number of coinage issued, it is supposed, would amount to about one hundred thousand.

The interest which attaches to the earliest day-dawn of civilization upon this planet, to human life in its first development in the far distant past, is

heightened by the perusal of these tokens which serve as a connecting link between those who live this day and have their being and those who lived three thousand years ago, who saw these works of art as they issued forth fresh from the coiner's hand; who ate, who drank, who slept, who died while these coins were still in their first infancy. Strange customs and curious ethnological facts, traits and coincidences have been displayed or developed upon coins, the records of the earth verified and brought to light. The world's epitome is here; history, geography, philosophy, religion, all bear their part.

Thrice happy he the gifted mortal who can lift the veil and read the secrets of the dusky night.

Stated Meeting, February 21, 1879.

Present, 8 members.

Vice-President, ELI K. PRICE, in the Chair.

Photographs for the album were received from Mr. John Ericsson, and Mr. William Ewing Dubois.

Letters of envoy were received from the Rev. F. C. Ager, Secretary A. Swedenborg Printing and Publishing House, New York; from the Board of Commissioners of the Second Geological Survey of Pennsylvania, and from the Meteorological Office of the Royal Society, London.

Letters of acknowledgment were received from the Museum of Comp. Zoölogy, Cambridge, Massachusetts (102); the Historical Society of Pennsylvania (102); the American Chemical Society, No. 11 East Fourteenth Street, New York City (65 to 102 inclusive); from Mr. William Bower Taylor, 457 C. Street, Washington (102); Wisconsin State Historical Society, Madison (102); Royal Geological Society of Ireland (100 and List); West Chester Philosophical Society (65 to 102 inclusive); New Hampshire Historical Society (102); Poughkeepsie Society of Natural History (102); Rhode Island Historical Society (102); Numismatic and Antiquarian Society, Philadelphia (102); New Jersey Historical Society (102); Georgia Historical Society (102); Davenport Academy of Natural Science (101, 102), and from numerous

members acknowledging the receipt of their copies of the Proceedings (102).

A letter was received from the Royal Library in Strasbourg asking for further exchanges and donations.

A letter was received from Mr. Austin Winsor, Librarian of Harvard College, one of the Committee of the Massachusetts Historical Society, asking permission to examine and compare the Lee MSS. in the Library with the Lee MSS. in the possession of the Cambridge Library in Gore Hall, and to publish desirable portions of the same.

On motion it was resolved that the Librarian be authorized to forward the Lee MSS. to the Committee, with permission to publish the same, returning the originals in good order to this Society.

Donations for the Library were received from the Zoologischer Anzeiger, Leipsig; the Bordeaux Society of Commercial Geography; Revue Politique, Paris; Mr. Thomas Clark, London; Editors of Nature; Museum of Comparative Zoölogy, Cambridge, Massachusetts; Cornell University; American Chemical Society, and Swedenborg Printing and Publishing Society, New York; Brooklyn Entomological Society; Franklin Institute, and Medical News, Philadelphia; Smithsonian Institution and Light House Board, Washington; Wisconsin Academy; Geological Survey of Pennsylvania; and the Ministerio de Fomento, Mexico; and in addition to the above, an engraving of a medal, found among Franklin's papers, was presented to the Society by Mr. J. Dickinson Sergeant, 420 Walnut Street, Philadelphia.

The death of Prof. Elia Lombardini, of Italy, December 19, 1878, aged 84 years (born October, 1794), was announced by the Secretary.

A communication entitled, "Further Confirmation of Prediction, by Pliny Earle Chase," was read by the Secretary.

A communication from a private letter respecting the great gas well lately struck at Murraysville, in Westmore-

land county, Pennsylvania, was read by the Secretary, as follows:

"The newspapers have doubtless informed you of a wonderful *gas well* recently bored in the village of Murraysville, in this county. It is about twelve miles north-west of this place, and is the result of an effort to obtain petroleum. At the depth of 1350 feet the rush of gas was so great that further boring was prevented. The tube now inserted in the well is five and a half inches in diameter, and through this the gas rushes with a roar that is heard distinctly at a distance of two miles.

"A few days ago I formed one of a party to visit it, and I will now try to convey to you an idea of its importance. In the 'derrick room' a horizontal tube has been placed on the top of the main tube, and at right angles with this, four two-inch tubes have been fastened, two of them on the north and two on the south side, each pair about six feet apart, thirty feet in length, and raised three feet above the common level. At night a match is applied to the open end of each tube, and instantly the whole country around is lighted up with a brilliancy that eclipses the moon at the full. At a distance of twenty feet the heat is intense."

Mr. Lesley explained that the boring commenced in the upper half of the Barren Measures, beneath the Pittsburgh coal bed, and penetrated the Carboniferous rocks, to a depth corresponding nearly with the horizon of the Berea Grit, which holds petroleum, in Ohio. This horizon of gas seems to correspond within one or two hundred feet with that of the well-known Leechburg gas well on the south side of the Conemaugh River, some miles north of Murraysville, described in Report of Progress (L) of the Second Geological Survey of Pennsylvania, page 121.

A communication entitled "A contribution to the Geology of the Lower Amazonas; by Orville A. Derby, M. S.," Assistant to the late Prof. Hartt, Geologist of Brazil, was read by the Secretary. (See page 155, above.)

Dr. König exhibited his improved chrometric apparatus; but on account of the small attendance of members, postponed a fuller description to the next meeting.

Pending nomination No. 872 was read and the meeting was adjourned.

Further Confirmations of Prediction. *By Pliny Earle Chase.*

(*Read before the American Philosophical Society, Feb.* 21, 1879.)

Th. von Oppolzer (Comptes Rendus, Jan. 6, 1879), gives elements, deduced from eight supposed planetary sun spots, which represent the fifth of my intra-Mercurial harmonic positions:

	Distance.	Time.
Von Oppolzer	.123	15.8 dys.
Chase, predicted.....	.120	15.1 "

This leaves only one vacancy in the chief interior series, the fourth place being still a "missing link." There is room, however, for an indefinite number of subordinate, or asteroidal harmonies, one of which has been confirmed already, by Gaillot's orbit for Watson's second planet:

	Distance.	Time.
Watson, II.....	.180	27.98 dys.
Chase.....	.183	28.48 "

The predicted harmonic denominator-difference was 4. But the denominator-difference in the principal planetary belt is only 2. The following table shows the agreement between prediction and verification:

Prediction.		Verification.	
$\frac{1}{13}$ of 3.469 =	.267	De la Rue, Stewart and Loewy	.267
$\frac{1}{17}$	.204	Kirkwood	.209
[$\frac{1}{19}$	.183	Watson, II	.180]
$\frac{1}{21}$	.165	" I	.164
$\frac{1}{25}$	.139	.....	....
$\frac{1}{29}$	.120	Von Oppolzer	.123

Six remaining terms of the prediction, with a denominator-difference of 144 ($\frac{1}{33}$, $\frac{1}{177}$, $\frac{1}{321}$, $\frac{1}{465}$, $\frac{1}{609}$, $\frac{1}{753}$), represent, as I have already shown,* harmonies of rotation and revolution, thus confirming my hypothesis that rotation is due to the collisions of orbital particles, in the neighborhood of a nucleal focus.

Lescarbault's observation is one of the three for which the exact time is given. Von Oppolzer attaches special importance to those observations, and to the confirmation which they derive from the five other observations which he has compared with them. His orbit, therefore, appears to be that of the *true* Vulcan for which Leverrier looked. If this proves to be the case, other names must be sought for the remaining planets, or for the harmonic sun-spot periods, if any of them do not represent permanent planets.

* Ante, xviii, 35-6.

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Stated Meeting, March 7, 1879.

Present, 18 members.

Vice-President, Mr. E. K. PRICE, in the Chair.

A photograph of Sig. Giovanni Capellini, of Bologna, was received.

A letter declining the appointment to prepare an obituary notice of the late Dr. J. B. Biddle, was received from Mr. H. C. Chapman, dated 2305 Walnut street, February 21, 1879.

A letter acknowledging the receipt of Byington's Choctaw Grammar in MSS., on loan, was received from Major J. W. Powell, dated Washington, Department of the Interior, March 5, 1879.

Letters of thanks, acknowledging the safe reception of two volumes of MSS. Lee Papers, on loan, was received from Mr. Justin Winsor, for the Massachusetts Historical Society, dated Cambridge, Gore Hall, February 27, and March 5, 1879.

Letters acknowledging receipt of Proceedings, were received from the Natural History Society, Frankfurt am M. (100 and List); and the Rantoul Literary Society (102).

Letters of envoy were received from the Central Physical Observatory, St. Petersburg, Jan., 1879; the Natural History Union at Riga, June 15, 1878; the Geological Commission, Berne, Nov. 19, 1878; the Swiss Society, Berne, Sept., 1878; the National Library at Florence; the Accademia dei Lincei, Rome; and the Meteorological Office in London, Feb. 9, 1879.

Donations for the Library were received from the Geological Survey of Victoria, Melbourne; Imperial Society of Naturalists, Moscow; Natural History Union, Riga; Central Bureau of Statistics, Stockholm; Zool. Anzeiger, Leipsig; Verein für Erdkunde, Dresden; Senkenburg Society, Frankfurt a M.; Oberhess. Gesellschaft Giessen; Société Helvétique, Lausanne; M. Henri de Saussure, Geneva; Herr L. Rütimeyer, Zurich; Commission Géologique Fed. Berne; R.

Venetian Institute, Venice; R. Academy of Sciences, Turin; R. Lombardy Institute, Milan; National Library, Florence; R. Geological Committee of Italy, Rome; R. Accademia dei Lincei, Rome; Sig. G. Capellini, Bologna; the late Prof. E. Lombardini, Milan; R. Academy, Brussels; Geological Society, and Revue Politique, Paris; Society of Commercial Geography, Bordeaux; R. Astronomical Society, R. Geographical Society, Society of Arts, Meteorological Office, and Nature, London; Philosophical and Literary Society, Leeds; Prof. Aug. R. Grote; Dr. W. J. Hoffman; American Journal, New Haven; Mr. Mansfield Merriman, New Haven; New Jersey Geological Survey; Germantown Dispensary; Journal of Pharmacy, Medical News, and Robinson's Epitomy of Literature, Philadelphia; Botanical Gazette, Madison Ill.; Wisconsin State Historical Society; and the Kansas State Historical Society, Topeka.

The death of Dr. J. H. McQuillen, at Philadelphia, March 3d, aged 53 years (born Feb. 12, 1826), was announced by Mr. J. Sergeant Price.

On motion, Dr. Kenderdine was appointed to prepare an obituary notice of the deceased.

The death of Mr. E. Spencer Miller, March 6th, aged years, was announced by Mr. Price.

On motion, Mr. Furman Sheppard was appointed to prepare an obituary notice of the deceased.

Dr. König made a communication upon his chromatic method of chemical analysis. Mr. Frazer and Dr. König discussed the subject.

Mr. Cope presented for deposit in the Library a copy of the last number of the Bulletin of the Geological and Geographical Survey of the Territories (Vol. V, No. 1); and in doing so invited the attention of the members present to certain statements which he had published therein, concerning the age and extent of Western strata belonging to the Permian and Tertiary epochs; and mentioned the characters of two species of a new genus of Perissodactyls which he desired to name *Anchisodon quadriplicatus* and *tubifer*.

Mr. Haupt exhibited photographs of the apparatus of the Pneumatic Tramway Engine Company, and read extracts from a report to show the greater economy and efficiency of this method of propulsion by compressed air, over the results obtained by the use of horse-power.

Pending nomination No. 872, and new nominations Nos. 874, 875, 876 and 877 were read, and the meeting was adjourned.

Stated Meeting, March 21, 1879.

Present, 13 members.

Vice-President, Mr. FRALEY, in the Chair.

A letter accepting the appointment to prepare an obituary notice of the late Judge John Cadwalader, was received from Mr. Peter McCall, dated March 13th.

Letters of acknowledgment were received from the Prague Observatory (101); the Meteorological Institute, Vienna (101); the Lisbon Academy (100; List); and the American Antiquarian Society, Worcester, Mass. (101).

Letters of envoy were received from Mr. W. B. Rawle, dated Philadelphia, March 7, 1879; and from the U. S. Naval Observatory, Washington, D. C., March 17, 1879.

Donations for the Library were received from the Melbourne Mining Department; Imperial Society of Naturalists, Moscow; Central Bureau of Statistics, Stockholm; R. Prussian Academy; Zool. Anzeiger, Leipsig; Revue Politique, Paris; Society of Commercial Geography, Bordeaux; Victoria Institute, and Nature, London, Literary and Philosophical Society, Quebec; Essex Institute; Mass. Historical Society; Boston Natural History Society; American Antiquarian Society, Worcester; Franklin Institute; Mr. Wm. Brooke Rawle of Philadelphia; U. S. Geol. and Geog. Survey; U. S. Naval Observatory; Dr. A. C. Peale; Mercantile

Library Association, San Francisco; Ministerio de Fomento, and V. Reyes of Mexico; and the R. Academy of History in Madrid.

The death of Mr. Henry J. Williams, at Philadelphia, on the 12th instant, aged 86, was announced by Mr. J. S. Price.

On motion, the Hon. M. Russell Thayer was appointed to prepare an obituary notice of the deceased.

The death of Mr. Jacob B. Knight, at Philadelphia, on the 10th instant, aged 48 years, was announced by Mr. Price.

On motion Dr. Charles B. Dudley, of Altoona, was appointed to prepare an obituary notice of the deceased.

A communicatien for the Magellanic premium, entitled "Epi- and Hypo-cycloidal Linkages," was presented, and was, on motion placed in charge of Prof. J. P. Lesley, for the examination of members, and for reference to the Board of Officers and Council; accompanying this communication is a sealed envelope, inscribed X. Y. Z.

Prof. Sadtler presented a paper entitled, "Analysis of a Calculus found in a deer, by Edgar F. Smith," and another entitled "On a new and delicate chemical test for iron: by Edgar F. Smith."

Mr. Henry Phillips, Jr., read a brief account of the earthquake which occurred at Aachen (Aix la Chapelle) on Monday, the 26th of August, 1868.

Dr. Norris exhibited a microphone, in which the grating sound frequently heard was prevented by the pressure of a small spring upon the carbon rod.

Pending nominations 872, 874, 875, 876, 877, were read.

Prof. Marks exhibited some pieces of coal representing the theoretical limits of the power of coal, measured by foot pounds and horse power.

And the meeting was adjourned.

Analysis of a Calculus found in a Deer. By Edgar F. Smith, Ph.D.

(*Read before the American Philosophical Society, March* 21, 1879.)

This rather interesting specimen was given me by Mr. Hall, student in the Medical Department of the University. It was found by him in the

pelvis of the kidney of a doe, which had been shot by a party hunting in the north-western portion of this State.

As the investigation of such calculi very frequently affords some interesting results, I subjected this specimen to both a qualitative and quantitative examination.

The size of the calculus was equal to that of the egg of a pigeon. It possessed a fawn color and consisted of three layers encircling a rather large nucleus, which presented a granular sandstone-like appearance. The layers were exceedingly thin, and seemed to have grown out from carbonaceous deposits, which were detected in various portions of the calculus.

Upon testing the nucleus qualitatively the presence of silica, ferric oxide, calcium oxide and phosphoric acid was clearly shown. The surrounding layers were found to contain calcium and magnesium oxides, phosphoric acid, sodium, potassium, uric acid and another organic compound. The latter was extracted from the finely divided material by boiling the same for some time with alcohol. The alcoholic filtrate yielded upon evaporation a gelatinous mass, which proved to be the sodium salt of an acid, which formed strong, colorless needles, exhibiting an hexagonal structure. Upon gently warming this crystalline mass with a grain or two of sugar and a drop of concentrated sulphuric acid, a beautiful purple color appeared. It is true, several acids occurring in the bile give the same reaction with sugar and sulphuric acid, but not any of them, that I am aware, possess the crystalline form of the above compound, nor yield a sodium salt similar to that mentioned above. The only acid which in the least corresponds to the previous description is that known as *Lithofellic Acid*, which was discovered a number of years ago* in a variety of the deer family. The want of sufficient material prevented me from making other and more decisive tests to discover the real character of this compound.

As the layers surrounding the nucleus were alike in chemical composition they were finely divided and a qualitative analysis made of the mixture.

Analysis.

43.15 %	P_2O_5.
.91 %	MgO.
2.60 %	Loss on ignition.
2 50 %	CaO.
51.00 %	alkaline oxides.
100.16	

Detection of Iron by means of Salicylic Acid. *By Edgar F. Smith, Ph.D.*

(*Read before the American Philosophical Society, March* 21, 1879.)

While working upon various substitution products of salicylic acid I had frequent occasion to filter solutions of the latter acid and its derivatives, and during this operation was continually annoyed by the constant appear-

* Annalen d. chem. u. Phar. 39, p. 237.
" " " " 242.
" " " 41, p. 150.

ance of the beautiful purple color, which is produced when salicylic acid is brought in contact with ferric salts in solution. The best quantitative filter paper invariably gave a deep purple coloration, and as the paper was considered pure enough for all analytical purposes, a few tests were finally made with a view of learning approximately the amount of iron which could be detected by means of salicylic acid. As the halogen substitution derivatives of the acid give purple color with ferric salts several of them were also experimented upon with the results recorded below.

A litre of water containing one grain of iron as chloride was employed in the preparation of the iron solutions.

Salicylic Acid and Iron Solution.

(1) The $\frac{1}{1000}$th of a grm of iron—in a drop or two of water—gave a distinct violet color, when mixed with as much salicylic acid as could be taken upon the end of a small knife blade. The acid was usually dissolved in three or four drops of alcohol. In the following tests the same quantity of acid as above was used.
(2) The $\frac{1}{40.000}$th of a grm of iron—treated as in (1) gave distinct purple coloration.
(3) The $\frac{1}{80.000}$th of a grm of iron—same as (2).
(4) The $\frac{1}{200.000}$th " " —decided purple color.
(5) The $\frac{1}{400.000}$th " " —distinct purple color.
(6) The $\frac{1}{3.200.000}$th " " —visible color.
(7) The $\frac{1}{12.000.000}$th " " —very faint coloration.

Metachlorsalicylic Acid (Fuses at 172°C.) *and Iron Solution.*

(1) The $\frac{1}{40.000}$th of a grm of iron—beautiful purple color.
(2) The $\frac{1}{80.000}$th " " —deep purple.
(3) The $\frac{1}{400.000}$th " " —faint purple color.
(4) The $\frac{1}{800.000}$th " " —faint purple color, but more distinct than that produced by ordinary salicylic acid.
(5) The $\frac{1}{1.600.000}$th " " —very faint color.

Dibromsalicylic Acid (Fuses at 218°C.) *and Iron Solution.*

The $\frac{1}{40.000}$th of a grm of iron—remarkably deep purple color.
The $\frac{1}{80.000}$th " " —very deep purple color.
The $\frac{1}{100.000}$th " " —distinct purple color.
The $\frac{1}{1.600.000}$th " " —barely visible color.

Upon adding a drop of a potassium sulphocyanide solution to one containing the $\frac{1}{80.000.000}$th of a grm. of iron a distinct red color was noticed. Farther tests were not made.

I noticed, however, that salicylic acid was a decidedly good reagent for iron in the presence of an excess of copper. In fact it is more delicate than sulphocyanide in such cases.

Laboratory of the University of Pennsylvania, March 21, 1879.

A Brief Account of the Earthquake at Aix la Chapelle (Aachen) on Monday, August 26, 1878. By Henry Phillips, Jr., A. M.

(*Read before the American Philosophical Society, March* 21, 1879.)

For several days prior to this occurrence the weather within a circuit of one hundred miles had been excessively rainy and quite cool for the season. Sunday, August the 25th, was chilly and lowering, although the barometer seemed inclined to rise. The next morning (Monday) dawned with rain falling in torrents, which continued at intervals during the remainder of the day and the whole of that night, driving the strangers visiting at Aix to seek refuge within their hotels and lodging houses. At about five minutes before nine o'clock in the morning a heavy shock of an earthquake, recurring in several waves, was experienced, and again, although of fainter intensity, at 9.05, 9.30 and 11.05, in the forenoon of the same day.

The first (viz., that at 8.55) was the most violent, moved in the direction from north north-west to south-south-east, the vibrations continuing in this plane for several seconds. A very heavy rolling, rumbling sound, apparently *not* subterranean, resembling that caused by the simultaneous passage through the streets of cumbersome deeply-loaded wagons, accompanied the disturbance.

In the upper portions of the dwellings the brunt of the shock was most forcibly felt; glassware and crockery were thrown down from their places and shattered on the floor, the window panes were rattled with great force, the bedsteads were swung in the direction of the motion. In the hotel where I was sojourning there was great consternation, and ladies rushed out terrified into the corridors, believing the building was about to fall upon them. I was at that moment ascending the grand stairway of the hotel, when I was suddenly seized, as I imagined, with a dizziness; everything reeled or rolled before me, the steps seemed to come towards and recede from me, and I seated myself, believing that I was suffering from an attack of vertigo. After a few seconds I perceived by the confusion of surrounding people that there was something really amiss. The oscillations became more and more violent, and it seemed as though the whole town was about to be laid in ruins. Many chimneys were demolished, the stone base of a weathercock on the Deaf Mute Asylum was thrown to the ground, a figure of an angel in the Church of the Holy Cross fell, striking terror into the hearts of the early worshipers, who fled in dismay, the officiating priest and his assistants escaping with great difficulty.

The long continuance of the first shock wrought a strong impression upon the inhabitants, who, pallid and trembling, rushed forth into the streets, while others stood with fixed gaze in the open air, as if paralyzed by fear or rooted to the ground. Some in their anguish fell upon their knees in prayer, calling loudly upon the saints in heaven for their intercession and protection. The market women, the letter carriers and all those whose business required them to be out at this early hour in the morning were witnesses of many ridiculous spectacles.

Surmounting the Polytechnic Institution there stands a colossal statue of Minerva, from which the hand and the point of her lance were broken off by the shock, and great rents were made in the bust, knees, head and the folds of its drapery. Two of the smaller turrets of the Treppen-haus portion of Rath Haus were said to be so seriously damaged as to involve their removal.

The barometer marked as follows :

Sunday, August 25, 10 P. M., 27.3.
Monday, August 26, 6 A. M., 27.282.
" " 9 A. M., 27.21.

The first shock is reported to have lasted about ten seconds, those which were later were less violent as well as shorter in their durations. It is a noteworthy fact that the last two earthquakes with which the city of Aachen has been favored have likewise taken place at an early hour of the morning : that of October 22, 1873, at 9.45 A. M., and that of June 24, 1877, at 8.50 A. M.

The disturbance was by no means a local one, but extended as far as the Hague, being experienced with considerable violence at Cologne, Brauweiler, Horrem, Forst, Altenberg, Herzogenrath, Stolberg, Elberfeld, Osnabrück, Barmen, Graffenich, Eschweiler, Düsseldorf, Nivelsteen, Lennep, Mountjoie, Linn, Jüngersdorff, Haum, St. Töuis, Reviges, &c., &c.

On Tuesday, August 27, the weather altered, being cool and showery in the forenoon and clear and bright in the afternoon and evening.

Stated Meeting, April 4, 1879.

Present, 15 members.

Vice-President, Mr. ELI K. PRICE, in the Chair.

A letter accepting the appointment to prepare an obituary notice of the late Henry J. Williams, was received from the Hon. M. Russell Thayer, dated Philadelphia, March 31, 1879.

A letter declining the appointment to prepare an obituary notice of the late Dr. McQuillen, was received from Dr. R. Kenderdine, dated Philadelphia, March 25, 1879.

On motion of Dr. R. E. Rogers, he was excused, and Dr. Agnew was appointed to prepare an obituary notice of the late Rev. Dr. Beadle.

A letter was received from Mr. Henry Bradshaw, Librarian

of the University of Cambridge, England, respecting certain numbers of the Proceedings of the American Philosophical Society in that University Library.

On motion, the Librarian was directed to complete a set for the University as far as practicable, and place the Library of the University on the list of correspondents to receive the Proceedings.

A letter of acknowledgment for (102) was received from the Museum of Comparative Zoölogy, Cambridge, Mass.

A letter from M. Léon Bigot, dated 9 and 10, Rue de Manoir Petit Queval pris Rouen, was read, requesting to be made a corresponding member.

Donations to the Library were reported from the Asiatic Society of Japan; Geological Survey of Japan; Swedish Bureau of Statistics; Zool. Anzeiger; Royal Accademia dei Lencei; Geographical Society, Annales des Mines, and Reveu Politique, Paris; Society of Commercial Geography, Bordeaux; M. Ch. Martins, Montpelier; London Nature; Canadian Naturalist; Essex Institute; Boston Natural Historical Society; Harvard College Observatory; New Bedford Free Public Library; American Journal of Science and Arts, and Prof. Norton, New Haven; Academy of Natural Sciences, Numismatic and Antiquarian Society, Mr. S. W. Roberts, Prof. F. Prime, Mr. Jas. J. Barclay, and Robinson's Epitome, Philadelphia; Johns Hopkins University, Baltimore; U. S. Naval Observatory and Department of the Interior, Washington; St. Louis Public School Library; and the Ministerio de Fomento, Mexico.

A donation for the cabinet was received from the Numismatic and Antiquarian Society of Philadelphia, with a letter from its Corresponding Secretary, Mr. Henry Phillips, Jr.

The donation consisted of a bronze medal struck to commemorate the Twenty-first Anniversary of the Society, and the Twelfth Anniversary of the Presidency of the Hon. Eli K. Price. On the obverse, the effigy of Mr. Price; on the reverse, the seal of the Society as described in a pamphlet given to the Library.

The death of Dr. George B. Wood, President of the Society since 1859, at his residence in Philadelphia, on the 30th ult., aged 82 years (on the 13th ult.), was announced by Mr. Fraley, with appropriate remarks, who then moved the following resolutions:

Resolved, That Dr. Alfred Stillé be requested to prepare and publicly deliver an eulogium on the life and character of Dr. George B. Wood, late President of the Society; and that a Committee of five members be appointed to make proper arrangements for the delivery of said eulogium.

Resolved, That as a testimonial of the respect of the Society for the memory of Dr. Wood, and of its regret for his death, the President's Chair be draped in mourning for six months.

Dr. Rogers, in seconding the motion, spoke of his own intimate relations with the deceased, and his two other illustrious contemporaries, Dr. Samuel Jackson, and Dr. Hugh L. Hodge, and eulogized the noble characters of this trio of great men.

Mr. Eli K. Price said that he remembered the two occasions on which were delivered the public eulogium on Dr. Caspar Wistar, fourth President of the Society, by his successor, Chief Justice Tilghman, and the equally eloquent eulogium on the latter pronounced in a solemn public meeting of the Society by Horace Binney, and he considered the present occasion one that deserved the attention of the Society, in an equal degree.

The motion being carried, the Committee of five was appointed as follows: Mr. Fraley, Mr. E. K. Price, Dr. R. E. Rogers, Prof. P. E. Chase, and Dr. Jos. Leidy.

The Secretary read extracts from a private letter from Mr. Leo Lesquereux, dated Columbus, Ohio, March 22, announcing the important discovery of a specimen of *Cordaites* bearing its fruit, a *Cordaicarpus*. The discovery was made in examining the last box of specimens of coal plants from the Darlington slate bed, sent by Mr. Mansfield, of Cannelton, Beaver County, Western Pennsylvania.

The following is an extract from the letter:

"Mr. Mansfield continues his systematic explorations with wonderful

persistency, and most valuable results. He sends me at least every month a box of specimens, and in each lot I find some novelties.

"In the last lot just received I find what has been searched for since botanists began to study the coal plants, namely, one of those large nuts generally found scattered, never attached to any support, but this time in distinct connection to a branch of *cordaites*, and just to the species on which it might be supposed to be found on account of the numerous branches of male flowers found upon other fragments. See Plate.....

"I believe that this discovery is important enough to be worth a record published in the Proceedings of the American Philosophical Society.....

"It would be advisable to have the specimen figured for a plate. Both fragments would fill, in representation with some enlarged parts, an octavo plate....."

The description accompanying the letter, is entitled "On a branch of *Cordaites* bearing fruit. By Leo Lesquereux."

On motion of Mr. Lesley the Secretaries were authorized to order a plate illustration, 8° size, to be published with the paper.

Prof. Chase, pursuant to notice, read a communication on some new estimates of solar and planetary mass and distance, derived from Lockyer's "Basic lines," Peirce's meteoric hypothesis, and the energy of light.

Prof. Frazer, in illustrating the curious way in which some arbitrary geographical lines, like that which separates Maryland and Pennsylvania, prove on examination to be real division lines between districts of different geological character, described the different structural and mineralogical features of the copper veins near Liberty, in Maryland, and those near Monterey, in Pennsylvania. He stated that samples from the former gave only 4 or 5 per cent. of copper, and samples from the latter as much as 28 per cent. He described minutely his own method of sampling these ores for the purpose of obtaining reliable averages.

To illustrate the deceptive aspect of some geological exposures, he described the Chicques rock near Columbia, which had been described as an anticlinal outcrop, whereas it is monoclinal to the southward, against a fault; and added, that he recently proved the fact further by a careful study of the south dips in the bluff on the opposite or western

side of the Susquehanna river, against which the stream was undercut for several miles.

In reference to the two uncertain forms discovered in the strata near the southern line of Lancaster, which Mr. Hall suspects to be fossil organisms, he said that it was desirable to have published drawings of them, costing about $35.

On motion the Scretaries were authorized to have such drawings made.

Pending nominations 872, 874, 875, 876, 877; and new nominations 878, 879, 880, 881 and 882, were read.

A letter was received from the President of the Historical Society of Pennsylvania, Mr. John William Wallace, dated 830 Spruce street, April 4, 1879, stating that Mr. Wm. Brooke Rawle and Mr. Charles Riché Hildeburn had been appointed to publish a continuation of the Penn-Logan Correspondence after 1711, and requesting permission to use the MSS. in the Library of the American Philosophical Society for that purpose.

On motion the request was granted under proper restrictions by the Librarian with a view to safety of the MSS.

Mr. Fraley announced that Dr. Wood had devised to the American Philosophical Society $20,000, for the purpose of erecting a fire-proof building, or for rendering the present hall fire-proof; and read a memorial to the Legislature, with the following resolution, which was adopted:

Resolved, That this Society will respectfully petition the Legislature for the release of the collateral tax on the charitable legacies and devises in the will of the late Dr. George B. Wood; and that the officers and members of this Society be requested to sign such petition, and to affix the corporate seal thereto.

After explanations from Dr. Rogers, the Chairman of the Committee on the Wootten process, on motion, that Committee was directed to make a final report on the subject at the next stated meeting of the Society.

And the meeting was adjourned.

On a Branch of Cordaites, bearing Fruit. By Leo Lesquereux. Plate I.

(*Read before the American Philosophical Society, April 4th,* 1879.)

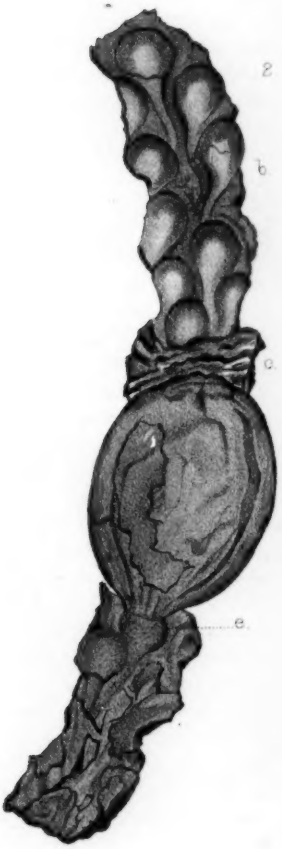
In a former paper, Proc. Am. Phil. Soc. March, 1868, I have given an account of the great work of Grand'Eury, especially considering his researches on the *Cordaites.*

Recent discoveries in the American Coal fields have afforded the means, not only of judging the value and the importance of the facts considered by the French author and of confirming his conclusions, but have also exposed in a new light some peculiar characters of these remarkable plants.

In considering the fruits of *Cordaites* (*Cordaicarpus*), p. 327, of the paper, it is remarked on *Antholites* or flowers of *Cordaites,* that except small nutlets, figured by Newberry, Dawson and Grand'Eury, and others, none of the large fruits commonly found in the Coal Measures have been found attached to stems or branches of *Cordaites,* nor indeed to any other kind of coal plants. Nutlets of *Antholites* are not even as large as peas, while the fruits of *Cordaites,* as Grand'Eury has figured them and as they are also represented, Pl. LXXXIII of the U. S. Coal flora,* vary in diameter from one to two and a half centimeters and therefore are, by their size, without correlation to those fixed upon branches of *Antholites.* Admitting as proved that these large nuts are derived from *Cordaites,* the question has been left by Grand'Eury what it was before for all the phyto-paleontologists from the oldest, who like Sternberg have considered the matter already, to those of our time. What is the relation of these fruits to the plants, their position, the mode of attachment, on stems, on branches, isolated and axillary, or in racemes, etc.? This question could be answered only by the discovery of a distinctly characteristic fragment of a *Cordaites* with the fructifications attached to it. It is to record that discovery, due to the persevering researches of Mr. I. F. Mansfield, who has done so much by systematic explorations in his coal bank of Cannelton, Pa., to promote the interest of the American coal flora, that I write this short notice.

The specimen bearing the vegetable remains is a piece of hard black shale, so appropriately split in the plan of stratification that it exposes both the upper face of the vegetable fragment and the counterpart. It represents a branch of *Cordaites costatus* (species figured U. S. Coal flora, Pl. LXXX, f. 1–3,), twelve centimeters long, bending down or like pending, nearly fifteen millimeters broad, marked in its whole length by prominent, kidney-shaped bolsters, support of pedicels or leaves, placed in spiral order, in the three ranked arrangement, enlarged, inflated in the upper part and abrubtly narrowed into a flexuous linear, lanceolate, long base. The nut or fruit is oval, three centimeters long from the point of attachment to the obtuse top, twenty-three millimeters broad, including its inflated border (three millimeters), broadly obtuse and entire at the top, rounded and narrowed at the base to a point of attachment or very short

* Published by the Second Geological Survey of Pennsylvania, 1879.



Thos. Sinclair & Son, Lith.

CORDAITES COSTATUS, LESQX.
BRANCH BEARING FRUIT

pedicel, five millimeters broad, distinctly joining the rounded subtruncate apex of one of the bolsters. The dividing of the shale in exposing and detaching the upper side of the fruit distinctly shows its mode of attachment by the continuity of the pedicel to the top of one of the bolsters.

The Plate I represents: Fig. 1, the fossilized part of the branch transformed into shining cannel coal. It is flattened to about two millimeters in thickness, the bolsters and their elongated base are in relievo. In the counterpart, fig. 2, the bolsters, concave and marked especially by the projections of the borders, are a little enlarged by compression. The part *e* is broken, as is also the base of the fruit in *d*. But the counterpart, fig. 2, has the impression of the whole fruit with its outside envelope, and the base is seen fixed upon the top of one of the bolsters, or rather of its impression in *e*.

This diagnosis and the figure of this branch of *Cordaites*, explain the position of the fruits as placed in spiral around a narrow branch, in a kind of long strobile. The close position of the bolster, serving as a support, and narrower than the fruits, at least when in maturity, could not allow them to remain upon the stem even until entirely ripe. They were forced out and soon falling off. They do not appear to have been axillary, for the bolsters do not bear any scar indicating the position of a leaf of *Cordaites* under the points of attachment of the fruits. The flowers were monoecious, even perhaps dioecious. A branch of the same species, *C. costatus*, figured Pl. LVIII, fig. 1, 1b, of the U. S. flora, bears racemes of male flowers whose pedicel is too slender for the axis of a strobile. The fertile flowers were in separate racemes, either on different trees or pending from another part of the same tree.

The discussion on the systematic relation of the *Cordaites* finds its place in the U. S. Coal flora. I will merely remark now that the position of these fruits in a kind of agglomeration in loose strobile, is comparable to the fruitifications of Cycadeæ, rather than to those of Conifers.

The Gingko, it is true, has nutlets resembling the fossil fruits by their shape. They are, however, much smaller, supported by a basilar cupuliform disk, with longer axillary fasciculate pedicels. Separate fruits of Cycadeæ have the size and form of the Cordaicarpes. Compare among many others, *Cycadosperum sulcatum*, in Heer, fl. Helv., IV, Pl. LVI, fig. 18–20 of the Jurassic.

I do not suppose, however, that the *Cordaites* are positively referable to Cycadeæ. They had compound characters, which have been later separated and diversely distributed in other vegetable tribes. They constitute therefore a peculiar separate group with analogies of various kinds. We find the same in the ferns of the coal, of which the multiplied references made to genera of our time, have proved a series of failures especially considering the fructifications. It is the same also with the Lycopodiaceæ as represented by Lepidophlois; with the Sigillariæ, the Calamodendræ, Asterophyllites, Sphenophyllum, Annularia and others.

Columbus, 22d March, 1879.

Solar Records. By Pliny Earle Chase, LL.D., Professor of Philosophy in Haverford College.

(*Read before the American Philosophical Society, April* 4, 1879.)

I. *Harmonies of Lockyer's "Basic Lines."*

From the third law of motion it follows, as a necessary consequence, that cosmical and molecular bodies act and react upon one another in accordance with laws of perfect elasticity. Hence, by introducing formulas of undulatory motion, results can often be speedily reached which would, otherwise, require the use of long and difficult analytical processes.

In previous communications I have shown:

1. That some of the most striking indications of nodal aggregation in the planetary system, are connected, by the laws which govern the relations between density and altitude in elastic atmospheres, with the nodal indications of the Fraunhofer lines.*

2. That the collisions of subsiding particles, from opposite diametral extremities of a condensing spherical nebula, tend to form shells or rings of nodal aggregation, at $\frac{3}{5}$ of the radial distance from the centre of the nebula.†

3. That centres of linear and of spherical oscillation, exert an important influence, both upon molar and upon molecular arrangements.‡ Professor Stephen Alexander had previously pointed out some instances of the results of spherical oscillation in the solar system.

4. That the nodal resistance of large cosmical bodies tends to form other nodal aggregations, at harmonic intervals, in accordance with the laws of musical rhythm which govern the vibrations of elastic media.§

5. That there are reasons for anticipating, in the fundamental oscillations of terrestrial elementary bodies, symmetrical harmonic evidences of the same laws as govern the harmonic nodes of elastic media and the harmonic grouping of planetary systems.‖

I have also shown, both from independent considerations and as corollaries from the foregoing laws:

6. That in paraboloidal aggregation,¶ there are three wave systems, with tendencies to nodal collisions and orbital aggregations in which the major axes have successive differences of $4\,x_0$.

**Ante*, xvii, 109, *sq.*; 1877: 294, *sq*; 1878.

† Ib. xvii. 100; 1877.

‡ Ib, x, 103; 1869.: xiii, 140 *sq.*; 1873.

§ xiii., 140, 193, 237; 1873.

‖ Ib., xii., 392 *sq.*; 1872.

¶ Ib., xvi, 507; 1877.

7. That centripetal energy $\left(f \propto \frac{1}{r^2}\right)$ varies as the fourth power of tangential energy in a circular orbit* $\left(v = \sqrt{fr} \propto \sqrt{\frac{1}{r}}\right)$.

Lockyer has published eight† "basic lines," which furnish illustrations of all these laws, or established harmonies.

The mean *vis viva* of the æthereal sphere of which Earth is the centre, tends (law 3) to form a node at .4 of Sun's distance from Earth, or at .6 of the same distance from Sun. Having already seen that the Fraunhofer line A is the exponential correlative of the planet Neptune, we readily find that this node is represented by a wave length of 4215.8 ten millionths of a millimetre. For (Laws 1, 5):

	Neptune.		Earth.		A.		
Log.	6442.985	:	log.	214.524×.6	: : 7612	:	4215.8

If we regard this value as a fundamental wave-length for terrestrial chemical elements, we may also (Laws 6, 7), regard $(\frac{1}{4})^4$ of $4215.8 = 16.468$ as a fundamental increment, for such harmonic undulations as may be excited in the elastic æther by inertial resistance.

The "theoretical" column in the following table, is constructed by simple combinations of the fundamental wave length and the fundamental increment.

Theoretical.	"Basic Lines."
$5269.8 + 3^3 \times 16.468 = 5418.0$	5416
$4215.8 + 8^2 \times 16.468 = 5269.8$	5269
	5268
$5170.9 + 2^2 \times 16.468 = 5236.8$	5235
$5022.7 + 3^2 \times 16.468 = 5170.9$	$b_3\ b_4$
$4215.8 + 7^2 \times 16.468 = 5022.7$	5017
$4^4 \times 16.468 = 4215.8$	4215

Lockyer does not give the wave lengths of b_3 and b_4. Gibbs‡ gives 5177 as the wave length of the b line. Law 2 is illustrated in the third theoretical line (5236.8), which represents $\frac{2}{3}$ of the interval between 5170.9 and 5269.8. These are both double lines in Lockyer's system. The doubling may, perhaps, be owing to the modification of the other activities by Law 2. Lines 2 and 5 (5269.8 and 5022.7) are directly connected with the fundamental line. All the incremental multipliers are integral squares. The difference between line 2 and line 5 is 15×16.468. The greatest square in 15 is 3^2, and the greatest square in $15 - 3^2$ is 2^2. These squares are the in-

* Ib., xlii, 245; 1873.

† Proc. Roy. Soc. Jan. 1879.

‡ Am. Jour. Sci. [2] xlvii, 4.

cremental coefficients for lines 4 and 3. The difference between lines 1 and 2 is the same as that between lines 4 and 5.

The greatest difference between the theoretical and measured values (5022.7—5017 = 5.7) is only $\frac{1}{40000000}$ of an inch. The closeness of the accordance may be more readily seen by dividing each of the theoretical values by 1.00028.

Reduced Theoretical.	Measured.
5416	5416
5268	5269
5268	5268
5235	5235
5021	5017
4215	4215

In some respects this symmetry seems even more remarkable than those which I found, more than eighteen months ago, in many of the chemical elements. They were, however, directly harmonic, being based on centrifugal relations to the centres of wave systems (Law 5). These are reciprocally harmonic, being based on centripetal relations to the surface of Sun's chromosphere.

Multiples of the fundamental increment often appear in the differences between the wave lengths of elementary spectra. The following instances, in elements for which I have already shown harmonic relations,* will serve as examples. The left hand columns contain exact multiple differences; the right-hand columns, measured wave-lengths :

Mercury.	
546.09	546.13
542.80	542.80
Lead.	
537.78	537.71
439.07	439.07
Lithium.	
479.69	479.48
459.93	459.93
Ruthenium and Iridium.	
545.34	545.44
530.52	530.52

Copper.	
578.67	578.67
529.27	529.30
522.21	522.24
465.75	465.64
Arsenic.	
617.54	617.54
533.55	533.55
611.67	611.67
578.73	578.73
Zinc.	
636.99	636.99
610.64	610.64
472.31	472.25

In the copper lines, the first theoretical difference is 30×1.6468; the second is $\frac{1}{7}$ as much; the third is the sum of the other two. In arsenic, the second line is $2^2 \times 3^4 \times 1.6468$.

* *Ante* xvii, 297; 1878.

II. *Spectral Estimates of Sun's Distance.*

I have further shown :

8. That the harmonic undulations of our atmosphere are such as to furnish a simple method of estimating Sun's distance, by means of barometric fluctuations.*

9. That approximate estimates of Sun's distance, may also be made from the harmonic disturbances of magnetism,† (chemical energy, light, sound, gt, gt^2, simultaneous attraction of Sun, Earth and other planets upon elastic fluids),‡ lunar distance and orbital time.§

10. That there are evidences of paraboloidal nucleation, connecting the Sun, each of the planets, the asteroidal belt, and the star *Alpha Centauri*.‖

11. That planetary rotation is merely retarded orbital revolution, through the collision of particles near paraboloidal or ellipsoidal foci.¶

12. That gt, when t is the time of cosmical or molecular semi-rotation, represents the limiting velocity between complete dissociation and incipient aggregation.**

13. That gt, for the principal planets in the supra asteroidal and in the infra-asteroidal belt (Jupiter and Earth), is determined†† by Sun's orbital influence ($\sqrt{gr}$); while gt, for the Sun, is the velocity of light.

14. That Jupiter is at the centre of the Neptuno-Uranian nebula ; Earth is at the centre of the belt of greatest density ; Sun is at the nucleal centre of the entire system.‡‡

15. That the frequency of oscillations in the violet rays, and the superficial gravitating energy of the Sun, are indicative of reciprocal action and reaction.§§

16. That successful predictions may be made from simple considerations of the principles which are involved in harmonic undulation.‖‖

All of these laws were found by means of the hypothesis that the undulations of an æthereal medium, when intercepted by inert bodies, tend to produce harmonic undulations (Law 4).

The discovery of the foregoing "basic" harmony, therefore, led me to look with confident expectation for such evidences of undulatory collision, between solar and terrestrial waves, as would furnish satisfactory grounds for new estimates of the Sun's mass and distance.

Beginning with the most far-reaching of all the indications (Law 10), and taking Earth's half radius as the unit and focal abscissa of a primitive

**Ante*, ix, 287; 1863.
†Ib., ix, 356, 367, 427, 487 ; 1864.
‡ Ib., xi, 103; 1869: xii, 392; 1872 : xiii, 142; 1873.
§ xiii, 398-400; 1872.
‖ Ib., xii, 519; 1872.
¶ Ib. xii, 406; 1872: xiv, 112; 1874.
** Ib. xiv, 111; 1874: xvi, 208, 496; 1876-7.
†† Ib. xii, 406; 1872.
‡‡ Ib. xvi, 497; 1877.
§§ Ib. xiii, 149; 1873.
‖‖ Ib. ix, 288; 1863: xiii, 238; 1873: xviii, 34; 1878.

paraboloid, the focal ordinate would be equal to radius. I then found (Laws 6, 7, 11, 12), that by comparing the *vis viva* of satellite revolution at Earth's surface ($\propto v_0^2 = gr$), with the *vis viva* of rotation at the primitive focal abscissa ($\propto v_1^2 = \frac{1}{4}$ of the square of the velocity of equatorial superficial rotation), we may obtain the equation:

$$\left(\frac{v_0}{v_1}\right)^2 = \frac{r}{y}, \quad \ldots\ldots(1)$$

in which y represents the distance traversed by a ray of light (compare Laws 13, 15), while a body, at the equator, would fall through the "fundamental increment" of the foregoing tabular comparison ($\frac{1}{2\,5\,6}$ of 4215.8 ten millionths of a millimetre). For,

$$v_0 = \sqrt{gr} = \sqrt{\frac{385}{12} \times \frac{3963}{5280}} = 4.907\ m.$$

$$v_1 = \pi \times 3963 \div 86165 = .1445\ m.$$

$$y = r\left(\frac{v_1}{v_0}\right)^2 = 3.436\ m.$$

$$t = \sqrt{.0000000016468 \div 4.8894} = .000018353\ sec.$$

Light traverses Earth's mean radius-vector in 497.825 *sec.* Therefore, according to this estimate, Sun's mean distance is

$$\frac{497.825y}{t} = 93{,}203{,}000 \text{ miles}. \quad \ldots\ldots(2)$$

A second approximation may be made by remembering that the basic lines are the reciprocals of harmonic lines, and comparing the æthereal volumes, or the reciprocals of the ratio of variability in tidal influence, $\left(\frac{1}{d}\right)^3$, at the points where the disturbing forces are greatest (the surfaces of the disturbing bodies). By the laws of elasticity, the æthereal undulations that are set up at any point, are propagated with uniform velocity. If we take the theoretical fundamental wave-length as our fundamental unit, and if we call the mean orbital distance which Earth traverses in the time ($t = .000018353$ *sec.*) of falling through the fundamental increment, the "orbital unit," we find that

$$\frac{\text{Orbital unit}}{\text{Fundamental unit}} = \left(\frac{\text{Sun's radius}}{\text{Earth's radius}}\right)^3 \quad \ldots\ldots(3)$$

For, representing Earth's mean radius-vector by x;

Orbital unit $= 2\pi x \times .000018353$ *sec.* $\div 1$ *year*.

$$\text{Fundamental unit} = \frac{4215.8 \times .0000000039371}{63360}\ m.$$

Sun's radius $= x \div 214.524$.

Earth's radius $= 3963\ m$.

Substituting these values in equation (3), we get

$$\frac{2\pi x \times .000018353 \times 63360}{365.256 \times 86400 \times 4215.8 \times .0000000039371} = \left(\frac{x}{214.524 \times 3963}\right)^3$$

$\therefore x = 92{,}579{,}000$ miles. $\ldots\ldots(4)$

It will be readily seen that equations (2) and (4) are entirely independent of each other. The true unknown quantity, or common unit of comparison, in each case, is the velocity of light. The comparison is drawn, in the first instance, between Earth's centripetal and centrifugal forces; in the second, between Sun's orbit-controlling influence upon Earth, and Earth's reaction upon Sun. That reaction must be exerted, either through an elastic medium, or by means of *quasi*-elastic forces. The elimination of the comparative unit, shows that the hypothesis of a luminiferous æther, or "æthereal spirit" as Newton termed it, accounts for inter-stellar, planetary, chemical, electrical, cosmical and molecular action. I do not, however, regard this fact as conclusive of the existence of such a medium, although it seems to lend the hypothesis a higher degree of probability than any previous investigations, and it requires, at least, *quasi*-elastic action.

The difference between the two results is less than one-half of one per cent. It would have been easy to assume values for the constants, which are within the limits of probable errors of observation, and which would have made the accordance exact. The value of Sun's radius ($x \div 214.524$) is deduced from Dr. Fuhg's estimate of Sun's apparent diameter. Three other estimates, which do not make so large an allowance for irradiation, are also included in the following table:

	Apparent Diam.	$x \div$ Sun's r.	x.
Dr. Fuhg.*	32′ 2.″99	214.524	92,579,000
British Naut. Al.	32 3. 64	214.451	92,531,700
American " "	32 4. 00	214.412	92,506,500
Lockyer's Astron.	32 4. 205	214.388	92,491,000

Among the numerous previous mechanical estimates that I have given, the one which accords most nearly with the two present determinations, was the one which was based upon thermo-dynamical considerations derived from the "heating energy of flames,"† and which gave

$$x = 92{,}639{,}500 \text{ miles} \ldots\ldots\ldots\

changes from meteoric influences, in proportion to its mass, so as to maintain a permanency of relative mass among the principal members of our system.

I have already pointed out various harmonic mass relations (Law 3), including the following equation involving figurate powers of the supra-asteroidal masses, as well as of their distances.*

$$\text{Saturn}^{10} = \text{Neptune}^{1} \times \text{Uranus}^{3} \times \text{Jupiter}^{6} \quad \ldots\ldots (6)$$

I have also called attention to the fact that these four planets, together with Earth and Sun, represent important centres of nebular or *quasi*-nebular influence, viz:

Neptune, centre of primitive annular condensation.

Earth, centre of belt of greatest density.

Sun, centre of nucleal condensation.

Uranus, centre of primitive "subsidence" collision (Law 2).

Jupiter, centre of Neptuno-Uranian nebula.

Saturn, nebular centre of mean planetary inertia. Saturn is also the centre of paraboloidal subsidence when Neptune was focal and Sun was at the vertex.

The report of Professor Pierce's lecture led me to look for some equation to connect the masses at the two remaining centres (Earth and Sun) with those of the two chief planets, and I soon found that

$$\text{Jupiter}^{3} = \text{Sun} \times \text{Earth} \times \text{Saturn} \quad \ldots\ldots (7)$$

This equation gives

$$\left.\begin{aligned} \text{Sun's mass} \ldots\ldots &= 328{,}600. \\ \text{“ parallax} \ldots\ldots &= 8.''832 \\ \text{“ distance} \ldots\ldots &= 92{,}549{,}000 \text{ miles.} \end{aligned}\right\} \quad \ldots\ldots (7_2)$$

Combining (6) and (7), we find

$$\text{Saturn}^{9} = \text{Jupiter}^{3} \times \text{Uranus}^{3} \times \text{Sun} \times \text{Earth} \times \text{Neptune} \quad \ldots\ldots (8)$$

The masses of Neptune and Uranus seem to be so related as to give them equal ratios between their present orbital momentum and the orbital momentum at their respective abscissas in the solar-stellar paraboloid ($\frac{3}{7}$ Neptune and $\frac{7}{8}$ Uranus).

$$\left.\begin{aligned} 7 \times \text{Neptune} &= 8 \times \text{Uranus} \\ \therefore \sqrt{\tfrac{7}{1}} \times \text{Neptune} &= \sqrt{\tfrac{8}{1}} \times \text{Uranus} \end{aligned}\right\} \quad \ldots\ldots (9)$$

Equation (8) may be stated under the form

$$\left(\frac{\text{Sat.}}{\text{Sun.}} \times \frac{\text{Sat.}}{\text{Ear.}} \times \frac{\text{Sat.}}{\text{Nep.}}\right)\left(\frac{\text{Sat.}}{\text{Jup.}} \times \frac{\text{Sat.}}{\text{Ura.}}\right)^{3} = 1 \quad \ldots\ldots (10)$$

Here the equation of planetary stability groups the centres in two sets, as in equation (7), the first introducing the first powers, the other the cubes, of the relative masses. The same exponential grouping also occurs in (3), but with linear factors instead of mass factors. If we consider that, in a rotating nebula, the time of rotation varies inversely as the square of the

* *Ante*, xlv, 652.

radius, and also inversely as the disturbing mass, the first group leads to the equation

$$\frac{\text{Earth} \times 1\text{ year} \times (\text{Neptune's r. vec.})^2}{\text{Sun} \times 1\text{ day} \times (\text{Earth's r. vec.})^2} = 1 \quad \ldots\ldots\ldots\ldots\ldots (11)$$

This equation gives

$$\left.\begin{array}{ll} \text{Sun's mass} \ldots\ldots & = 330{,}375. \\ \text{“ parallax} \ldots\ldots & = 8.''816 \\ \text{“ distance} \ldots\ldots & = 92{,}717{,}000 \text{ miles.} \end{array}\right\} \ldots\ldots\ldots (12)$$

In considering this and other relations of mass to æthereal disturbance, it is well to remember that the simple disturbance varies as the mass; the *vis viva*, or radius of consequent oscillation, as the square of the mass; and the consequent orbital period, as the cube of the mass.

By introducing the vector-radii also into the cubical factor of (10) and designating secular perihelion, mean perihelion, mean aphelion, secular aphelion, respectively, by subscript 1, 2, 3, 4, 5, we find

$$\left.\begin{array}{l} \dfrac{\text{Sat.}_3 \times \text{Sat.}_4}{\text{Jup.}_2 \times \text{Ura.}_3} = 1 \\ \\ \dfrac{\text{Sat.}_2 \times \text{Sat.}_4}{\text{Jup.}_3 \times \text{Ura.}_2} = 1 \end{array}\right\} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (13)$$

The greatest deviation from exactness, in the first of these equations, is less than $\frac{1}{8}$ of one per cent.; in the second, less than $\frac{1}{16}$ of one per cent. The mean deviation, in the square root of the product of the two equations, is only $\frac{1}{32}$ of one per cent.

We see by (5) and (13), as well as by ordinary astronomical investigations, that questions of relative mass are intimately connected with those of orbital eccentricity. One of the most interesting evidences of such connection, in this special line of investigation, is to be found in the position of the mean fulcrum of the system, or centre of gravity of Sun and Jupiter, together with the significance which it lends to equations (5), (6), (8), (13), as well as to the fundamental increment which is the ground of equation (3). The orbital *vis viva* has lengthened the radius-vector of simple equilibrium by $\frac{1}{16}$ of its value. For $5.2028 \times 214.524 = 1116.125$; $\frac{15}{17}$ of $1116.125 = 1050.471$. The limit of synchronous radial and circular oscillations is at $2r$. Deducting 2 from 1050.471 we find

$$\frac{\text{Sun's mass}}{\text{Jupiter's mass}} = 1048.471 \ldots\ldots\ldots\ldots\ldots\ldots\ldots (14)$$

Equations 7, 8 and 9 give the following theoretical values, for Uranus and Neptune, which I compare with Newcomb's:

Sun +	Theoretical.	Newcomb.
Uranus.....	22116	22600 ± 100
Neptune.....	19352	19380 to 19700

Newcomb gives two estimates for Neptune, one (19380 ± 70) from satellite, the other (19700) from perturbations of Uranus. The latter agrees

precisely with the theoretical ratio (9) between the two planets, while the former is presumably more accurate.

The uncertainty in regard to all the planetary masses, except that of Jupiter, is still so great, that it is impossible to tell how closely they are represented by the equations for the combined central activities (6, 7, 8). The latest investigations of Leverrier and Newcomb, however, show a closeness of approximation which is remarkable, in view of the wide discrepancy in some of the values. Leverrier's mass-denominators, based on the old parallax (8.″57), are: Neptune, 14400; Uranus, 24000; Jupiter, 1050; Saturn, 3512; Earth, 354936. The accordance with the combined equation (8) is within $\frac{1}{8}$ of one per cent. if we deduce Earth from the other masses; within $\frac{1}{14}$ of one per cent. if we deduce Saturn.

If we look to the partial equations, (6, 7), we find that Saturn's mass, as deduced from Neptune, Uranus and Jupiter, (6), is about $\frac{3}{4}$ of one per cent. greater than Leverrier's assumption, and about the same amount less than Bessel's, which was adopted by Newcomb. *The mean of the two results shows an exact accordance*, as follows:

	Deduced.	Assumed.
Leverrier	3488.3	3512.0
Newcomb	3525.0	3501.6
Mean	3506.6	3506.8

The results of the second partial equation, (7_2), may confidently await the verdict of the observations upon the last transit of Venus. No other estimate can now claim a greater degree of probability. It may be, as Leverrier suggests, that a small portion of the mass may belong to a group of minute asteroids, near Earth's orbit, but there is no present likelihood that any material inaccuracy will ever be found in the equation which connects the two principal intra-asteroidal centres with the two principal extra-asteroidal centres.

E. Wiedemann's experiments upon the illumination of gases by electricity,* have convinced him that the electric discharge may excite a considerable increase of the *vis viva* of oscillation in æthereal envelopes, without increasing the *vis viva* of the enclosed molecules. Peirce's meteoric hypothesis opens an immense field for new physical speculation and investigation. If the æther is material, where shall we draw the boundary between æthereal and meteoric influences? If cosmical masses have been formed by paraboloidal aggregation, may not radiation also be paroboloidal? The solar forces of association and dissociation seem to be almost exactly balanced, and the law of equal action and reaction may, perhaps, free the science of thermodynamics from the opprobrium of its apparent tendencies to universal aggregation, stagnation and death.

*Wied. Ann., vi, p. 301.

Obituary Notice of Robert Frazer. By Persifor Frazer, Jr.

(*Read before the American Philosophical Society, February 7, 1879.*)

ROBERT FRAZER was born December 29, 1818, at his father's house in Newtown Township, Delaware County. His father, Robert Frazer, was a lawyer of excellent standing and distinguished for his knowledge of land law, who had served several times as a member of the House of Representatives of this State.

The elder Robert, son of General Persifor* and Mary Worrall Frazer, was three times married, as follows:

On May 3, 1798, he married Sarah Ball, who died without issue, June 21, 1800.

On October 15, 1803, he married Elizabeth Fries, daughter of John and Anne Fries, by whom he had six children, three of whom died under the age of one year, and the others were, Anne Fries, Persifor, and John Fries, of whom only the second survives.

On February 11, 1818, he married Alice, widow of Eli Yarnall and daughter of Joseph and Sarah Pennell, by whom he had but one child, the subject of this brief notice.

The boy was named originally Joseph Pennell, but on the death of his father, January 20, 1821, his name was changed to Robert.

From that date he continued to live on his mother's farm, near West Chester, till her death in 1825 or 1826, when he spent some time in Philadelphia and attended Dr. S. Crawford's school.

In 1834–38 he went to school in Pittsfield, Mass., and finally completed his education at Norwich University, a military academy in Vermont, under the direction of Capt. Partridge.

He graduated after having completed courses in Civil Engineering and in the Arts and Sciences.

In 1838 he joined the corps of Engineers which was then engaged in laying out the Reading Railroad, and was in charge of the second division above Reading, remaining there until the completion of the road.

In the autumn of 1846 he went to Europe and remained about a year, and upon his return commenced the study of law in Reading, in the office of Judge Jones.

On being admitted to the bar, he removed to Philadelphia to practice, and not long after this held the office of Prosecuting Attorney for Delaware County for some time.

In 1846 he was married to Miss Jane Biddle Wood (daughter of Samuel and Fanny Collins Wood, and grandniece of Marks John Biddle) who was born February 14, 1820. The marriage was celebrated by the Rev. Edmund Leaf, Rector of Christ's Church, in Pottstown, Montgomery County.

On July 22, 1849, Robert Frazer was born as the first issue of this marriage.

* General of State Militia after the Revolution. Lt.-Col. in the American army during the Revolution.

PROC. AMER. PHILOS. SOC. XVIII. 103. 2D. PRINTED JUNE 3, 1879.

A daughter, Fanny (now Mrs. Herbert Welsh), was born on October 4, 1852.

Almost at the same time in this year (1852) Robert Frazer was elected Secretary and Treasurer of the Camden & Atlantic Railroad, in the construction of which road he had been previously engaged as consulting engineer.

In November, 1863, he was elected President of the Company, which office he retained till the fall of 1873.

It will ever remain as a monument of his devotion, zeal and efficiency in the management of this road that its stock advanced during his tenure of the chief office from an almost unsaleable commodity to a position of prominent favor for such a road.

Upon his retirement from the Camden & Atlantic Railroad he was called to the presidency of the Wilmington & Reading (afterwards known as the Wilmington and Northern) Railroad, and while holding this position he died suddenly of a stroke of apoplexy, on May 4, 1878, at 15 minutes past 6, P. M.

On the 4th of May, 1878, he was apparently in the best health and in buoyant spirits and attended to all his duties with ease. He was expected at the house of his daughter, Mrs. Welsh, to tea, when a short time before the hour a messenger arrived announcing that he had a severe headache and would not be able to come. Very shortly after this he died.

He was a man who was characterized by many salient traits, among which none was so striking, by reason of its rarity, as his gentleness and sweetness of disposition. No one ever observed him in his relations to other men without envying him the kindly tone, the liberal view and the winning manner with which he either opposed or endorsed the sentiments of others. His normal condition of features was the border of a smile, and his heart was full of sunshine, which his cheery words sprinkled like drops of water on those about him. One is tempted to dwell on a character like this, for the memory of it causes always an agreeable sensation: yet it may be thought that the ties of consanguinity render the writer a too partial witness. But it is not so. All who knew Robert Frazer, knew him as a patient, forbearing, kind and cheerful friend, a model of content, and a well-spring of pleasure to those by whom he was surrounded.

His tastes were those of a cultured man, and his mind had that quality of interest and curiosity which kept him actively seeking information and *au courant* with the affairs of the day. Every new turn of the kaleidoscope of the times which developed some new and beautiful idea, some discovery, or some invention, delighted him whether it was or was not in the direction of his professional work.

He was one of those earnest soldiers of ideas who, whether they serve religion, their country, or science, show alike their sense of the solemn meaning of the march of events. He believed in the *duty* of man to *labor* for and with that evolution of new forms of truth which is but the measure of onward progress, even though the progress be in any case inevitable;

and he believed also unwaveringly in the majesty and goodness, the fitness and worthiness of that which the future was to bring forth.

Many find this state of mind inseparable from a mood of seriousness, if not of asceticism; Robert Frazer did not. No one realized more fully the serious side of life, but he had also learned (if it was not taught him by instinct) the phariseeism of gloom as an emblem of respect for truth. If ever man served his God with the grateful incense of smiles and joyfulness it was the subject of this sketch.

This interest in the affairs of the world around him led him naturally to cultivate various branches of science, as an amateur, and he preserved the keenest interest in them to his last hour, though his engrossing occupations forbade him to tread the path of original investigation.

Microscopy and Entomology always had great attractions for him, and for several years previous to 1867 he was President of the Entomological Society of this city.

He was elected a member of the Academy of Natural Sciences in 1866, and when his duties allowed was frequently seen within its halls on its nights of meeting.

In 1873, he was elected a member of this Society.

Of his inner life as a member of a family; of his charm within that circle, shut out from the gaze of the world, I may not speak. But were it permitted to pursue this theme a far juster picture of the man could be presented them in these few poor lines in tribute to his memory. Yet those who knew him in the world can easily imagine how bitter was the loss of this friend, who ever dispensed consolation and cheer, to those whom he most dearly loved, and to whom his whole life was a pattern of self-sacrifice, of manly and healthy virtue, and of the warmest human sympathy.

Stated Meeting, April 18, 1879.

Present, 19 members.

Vice-President, Mr. FRALEY, in the chair.

A letter declining the appointment to prepare an obituary notice of Dr. Wood, was received from Dr. Stillé, whose communication was on motion referred to the Committee on the eulogy.

A letter accepting the appointment to prepare an obituary notice of Dr. Beadle, was received from Dr. Agnew, dated April 17.

A letter requesting permission to use the Logan-Penn

MSS. in the Hall of the Historical Society, was received from the President of that Society, Mr. J. W. Wallace.

On motion, the Librarian was authorized to entrust, 1. the Wm. Penn's Letters and Ancient Documents; 2. Logan Papers, Vol. 3; 3. Logan Papers, 399-3, to the care of the Committee of the Historical Society, on written receipt for the same and obligation to return without unnecessary delay.

Letters of acknowledgment were received from the Yale College Library (Trans. XIV, XV), and the Rev. Stephen D. Peet, Unionville, Ohio (Proc. Vols. VIII to XVII complete).

Letters of envoy were received from the Imp. Bot. Garden, St. Petersburg, March 4, 1879, and from Prof. Ira Remsen, of Johns Hopkins University, April 10, with the first number of the American Chemical Journal, asking for exchanges.

On motion, Dr. Remsen's name, as Editor, was ordered to be placed on the List of Correspondents to receive the Proceedings henceforth.

Donations for the Library were received from the Botanical Garden, St. Petersburg; the Russian Geographical Society; Prussian Academy; Zoologischer Anzeiger; Flora Batava; Belgian Academy; Society of Geography, Paris; R. Astronomical Society; Nature; Boston Soc. Nat. History; Brooklyn Entomological Society; Am. Jour. of Otology; Astor Library; N. Y. Chemical and Historical Societies; Franklin Institute; Jour. of Pharmacy; Medical News; Jour. Med. Sciences; Am. Chemical Journal; State Mineralogist of Nevada; and Sig. V. Reyes, Mexico.

The death of Dr. Isaac Hays, at Philadelphia, one of the oldest members and former secretaries of the Society, April 15, aged 83 years, was announced by Mr. Fraley.

On motion, Dr. Brinton was appointed to prepare an obituary notice of the deceased.

Pending nominations 872, 874 to 882 were read, Nos. 872, 874 to 877 were spoken to and balloted for.

The Chairman of the Committee on a Premium for an

Anthracite Dirt Burning Process, Dr. R. E. Rogers, reported progress. (See Minute book.)

There being no other business, after scrutiny of the ballot boxes, by the presiding officer, the following persons were declared duly elected members of this Society:

William H. Greene, M.D., of Philadelphia.

Mr. Arthur Erwin Brown, of Philadelphia, Superintendent of the Zoological Garden.

Carl Seiler, M.D., of Philadelphia.

Dr. Middleton Goldsmith, of Rutland, Vt.

Mr. Richard Wood, of Philadelphia.

And the meeting was adjourned.

Stated Meeting, May 2, 1879.

Present, 13 members.

Vice-President, Mr. FRALEY, in the chair.

Letters accepting membership were received from Dr. Carl Seiler, dated Philadelphia, April 22, 1879; Dr. Wm. H. Greene, dated Philadelphia, 1812 Green St., April 21; Mr. Arthur E. Brown, Zool. Soc., Fairmount Park, April 21, and Dr. M. Goldsmith, dated Rutland, Vt., April 22,

A photograph of Mr. Edward Goodfellow, was received for insertion in the Album.

A letter accepting the appointment to prepare an obituary notice of the late Dr. Isaac Hays was received from Dr. Brinton.

A letter enclosing a communication to be read at the meeting was received from Prof. Daniel Kirkwood, of Bloomington, Monroe Co., Indiana, dated April 19, 1879.

Letters of acknowledgment were received from the Kentucky Historical Society (Proc. No. 102); Buffalo Society of Natural Sciences (102); Kansas State Historical Society

(102); Smithsonian Institution (102); Essex Institute (102); Davenport Academy (102); Providence Franklin Society (102); and the Liverpool Lit. and Philo. Society (Nov. 25, 1878, 100 and 101), and postal cards from many members.

Letters of envoy were received from the Lit. and Philo. Society of Liverpool, and from the Société des Sciences de l'Agriculture de Lille, dated April 1, 1879.

A letter offering an exchange of publications was received from the Director of Studies of the Ecole Polytechnique, dated Paris, April 6, 1879.

Donations for the Library were reported from the Asiatic Society of Japan; the Royal Academy dei L. at Rome; Dr. Prof. F. J. Lauth, of Munich; the Vaudoise Society; Zoologischer Anzeiger; Royal Belgian Academy; Revue Politique; Com. Geog. Society at Bordeaux; R. Astronomical Society; London Nature; Lit. and Phil. Society of Liverpool; Mr. James W. Barclay; Silliman's Journal; Penna. Historical Society; Am. Journal of Pharmacy; Prof. Andrews, of the Geol. Survey of Ohio; and Prof. Joseph LeConte.

A communication was read by the Secretary, entitled, "Meteoric Fireballs seen in the United States during the year ending March 31, 1879, by Prof. Daniel Kirkwood."

Prof. Cope exhibited a life-size drawing of a vertebra of a new species of *Camelosaurus*, for which he proposed the name *C. leptodirus*, and showed in what it differed from the vertebræ of *C. supremus*.

Prof. Marks exhibited a beautiful "Compound Compass," made under his direction by Wm. Young & Sons, for the use of the Geological Survey in drawing tangents and curves of very great radius, or parallels and meridians, and explained how this invention of Peaucellier could be modified for other uses.

Mr. Lesley exhibited a large distemper map of Pennsylvania, painted recently to exhibit to the Legislature the progress of the Survey. Also the first bound copy of Lesquereaux's Coal Flora Atlas of 87 plates, just published by the Board of Commissioners of the Geological Survey.

Prof. Frazer read parts of a correspondence which he had had with Mr. Meehan, respecting the local cause of change of color in autumn foliage.

A letter from Prof. Lauth, of Munich, was read, relating to his recent investigations and proposed publication of a new work on Egyptology.

Pending nominations, Nos. 878 to 882 and new nomination No. 883 were read.

Mr. Fraley, for the Finance Committee, reported that he had collected and paid over to the Treasurer, the quarterly interest on the Michaux Legacy due April 1, amounting to $133.07.

A discussion on the Wooten process then took place, pending which the meeting was adjourned.

On Meteoric Fireballs seen in the United States during the year ending March 31, 1879. By Professor Daniel Kirkwood.*

(*Read before the American Philosophical Society, May 2, 1879.*)

The following paper does not claim to present a complete list of the fire-balls which have appeared in our entire country during the last twelve months. It includes, however, all that have been brought to the writer's notice. Of those described only three can be certainly classed as detonating meteors, and in no case has an explosion been followed by a fall of meteoric stones; at least, no aerolites have been actually discovered.

(1.) 1878, June 3, 2h. 59m., A. M.—This meteor, observed at Chicago, by Prof. E. Colbert, was about equal in apparant magnitude to the moon at four days old. Its course was from near the zenith to a point about 4° above Beta Cassiopeiæ. Near Alpha Cassiopeiæ it exploded into seven or eight fragments.†

(2.) 1878, June 6th, 9h. 25m. (local time).—On the evening of June 6, Mr. Geo. H. E. Trouvelot, at Cambridge, Mass., saw a very large meteor which passed directly over Omicron Ursæ Majoris, and disappeared just below Eta in the same constellation. It was pear-shaped, the greatest and least diameters being in the ratio of 4 to 3, and it left behind it a long bright train. About three or four seconds after its appearance it burst into five

* No. 6 (January 20, 1877) of the fireballs described in my paper read before the A. P. S., March 16, 1877, was found, after the article was in type, to be a newspaper hoax.

† Letter from Prof. E. Colbert, dated June 3, 1878. See also the Sci. Obs. for July, 1878, p. 3.

or six fragments, each of which assumed the same form as the original meteor. "The preceding portion was of a crimson red hue, quite brilliant, and not dissimilar to the Strontian flame. The following portion was of a bluish violet color, which merged into that of the trail. This latter was composed of globules, each succeeding following one being of a more and more subdued violet, and finally not distinguishable from the color of the sky."*

(3.) 1878, August 11, 10h. 10m. (Indianapolis time).—A few minutes after 10 o'clock on Sunday evening, Aug. 11, Rev. John A. Bower, of Bloomington, Indiana, saw a large meteor near the eastern horizon. Mr. B. had just taken a position facing an eastern window. The meteor when first seen was almost exactly east of Bloomington, perhaps two or three degrees south of east, and 10° above the horizon. Its motion was from south to north, and the length of its apparent track was 20° or 25°. The first half of its course was but slightly inclined to the earth's surface; the inclination, however, became sensibly greater towards the point of disappearance, which was N. about 70° E., and very near the horizon. The apparent diameter of the meteor was about one-third that of the moon. The motion was extremely rapid; the time of flight not exceeding two seconds. No detonation was heard at Bloomington, nor was the meteor seen to separate into fragments at the time of disappearance.

The observations of Mr. Bower were given me verbally. To verify their accuracy I placed myself in the position which he occupied, and had him point out the meteor's course as he had seen it. The foregoing statement, I am satisfied, must be very nearly correct, except as to the time of flight, which is admitted by the observer to be very uncertain.

The same meteor is supposed to be described in the following telegrams which appeared in the newspapers of the next Tuesday morning:—"Titusville, Crawford Co., Pa., August 12. A beautiful meteoric display was witnessed from here last evening. The meteor made its appearance in the west at 10.30, moving in a northerly direction. It was of a greenish color and shone with great brilliancy, lighting up the entire surrounding country with a light that for the time prevailed over that of the full moon. Its appearance was only momentary, when it burst and divided into three fragments, two of which assumed a reddish color. Calculating from the time the explosion was seen until it was heard, the meteor was about 25 miles distant." "Oil City, Venango Co., Pa., August 12. A meteor of unusual brilliancy passed here last evening a few minutes after 10 o'clock. It was nearly twice the size of a cannon ball. Its course was north."

All accounts agree that the meteor's course was northward. It was seen to the west of Titusville; and as the final explosion occurred about 25 miles from that city we may conclude that the track terminated over Crawford County, Pa. The observations at Bloomington, Indiana, indicate that the body first became visible over West Virginia. The distance directly east from Bloomington to the meridian which bounds Venango County, Pa., on the west, is 348 miles. Hence the meteor's altitude when first

* Science Obs., June, 1878.

seen was about 77 miles. This, it must be admitted, is somewhat uncertain, but we may safely conclude that it was not less than 70 miles nor more than 85. The length of the visible track was between 160 and 175 miles. The estimated time of flight was probably too short; but the great velocity appears to indicate a hyperbolic orbit.

(4.) 1878, September 16, 9h. 0m., P. M.—This meteor was observed by Mr. Benjamin Vail, of Henryville, Clark County, Indiana. It was first seen near Gamma Ursæ Majoris, and it passed over Delta in the same constellation. Its apparent diameter was about one-fourth or one-fifth that of the moon.*

(5.) 1878, November 12, 7h. 0m., P. M. (local time.)—Washington, Indiana. Mr. D. Eckley Hunter, Principal of the High School, of Washington, Daviess County, Indiana, was, with several of his students, watching for shooting stars on the evening of November 12, when precisely as the town clock was striking seven, a large fireball appeared very close to Vega, passed in a sourtherly direction through the milky-way, and disappeared about 20° N. W. of Jupiter. Its motion was very slow; the time of visibility being estimated by Mr. Hunter at 10 seconds. Its apparent diameter was about two-thirds that of the moon. What struck Mr. Hunter as especially remarkable was the sharply defined disk which the meteor presented, up almost to the very moment of its disappearance.†

(6.) 1878. November 14, 3h. 30m., P. M.—In the New York Semi-Weekly *Tribune*, of December 10, 1878, Mr. Thomas Whitaker, of Hillside Farm, Mass., reports the appearance of this brilliant meteor as observed by himself. The sky was very clear at the time, and the meteor was seen in bright sunshine. It was due south from the place of observation.

(7.) 1878, December 30.—A few minutes before 7 o'clock (Indianapolis time) on the evening of December 30, 1878, a large meteor was seen in Indiana, Ohio, and Pennsylvania. So far, however, as known to the writer, the only observations sufficiently prescise to be available in determining the height and direction of its path were made at Anderson, Madison County, Indiana; Washington, Washington County, Pa., and Wooster, Wayne County, Ohio.

Anderson, Indiana, Lat. 40° 5′, Long. 8° 28′ W.—The observations at Anderson were made by Mr. Frederick E. Dickinson, a member of the Senior Class, in Indiana University.‡ Mr. D. was in the street, walking eastward, when the meteor appeared in front of him, a few degrees N. of E., at an altitude of not less than 15° nor more than 17°. As the meteor passed behind a building the point of disappearance could not be determined. The apparent diameter was one-fourth that of the moon, and the time of flight was estimated at two seconds or probably a fraction less.

Washington, Pa., Lat. 40° 10′, Long. 3° 12′ W.—The phenomenon as

* Letter from Mr. Vail.

† Letter from Mr. D. E. Hunter.

‡ The meteor was seen by others in Indiana, but the descriptions given were nothing more than vague guesses in regard to its size and general direction.

PROC. AMER. PHILOS. SOC. XVIII. 103. 2E. PRINTED JUNE 3, 1879.

seen in Washington, is described in the following letter from the Professor of Mathematics in Washington and Jefferson College:

"WASHINGTON, PA., February 1, 1879.

"PROF. D. KIRKWOOD, *Dear Sir*:—The fact of the appearance of a meteor here some time ago, may be of interest to you I set down the facts as I learned them at the time, and intended to have written you sooner. About 7 P. M., Washington, Pa. time, December 30th, a brilliant meteor was seen here. The account which I have was given me by a young man, Mr. A. M. Gow, Jr., who has given me, I have no doubt, a very fair statement of what was to be seen at that time. He was walking eastward on the south side of the street, so that he was in the shade of the buildings; the moon shining brightly at the time. Suddenly a light shone about him as if an additional lamp had been lighted close behind him. He did not turn immediately to look, but when he did he saw a meteor about the size of the moon as he thought by comparing his impression with the half-full moon immediately afterwards. It was of a slightly greenish color, but just as it disappeared it became reddish. The place in which he saw it, as far as I can judge, was about Alpha Cygni, and the place of its disappearance was about Alpha Lyræ. If so, you see its course was W. N. W., and it was observed through 24° of its path. The meteor had been visible a little time, however, before Mr. Gow turned to look. It was seen by three others here that I know of. Yours Truly,

"D. J. MCADAM."

Observations at Wooster, Lat. 40° 50′ *N., Long.* 4° 56′ *W.*—Professor Samuel J. Kirkwood, of Wooster University, had a good view of the meteor, which he describes as the most brilliant he has ever seen. It was greatly elongated, and the apparent diameter at right angles to its path was half that of the moon. The point of the meteor's first appearance and also the first part of its track were accurately observed through large tree-tops.* Prof. Kirkwood gives the following angles as the result of careful measurement with a surveyor's transit:

"First appearance, east, alt. 50°. Disappearance, S. 13° E. alt. 13°." Prof. K. remarks: "The first appearance is, I am satisfied, quite exact, and entirely reliable. I am not so confident of the observation at disappearance. The meteor exploded when about S. 33° E."†

According to the observations at Wooster and Anderson the meteor became visible at a height of 72 miles over a point in Columbiana County, Ohio, Lat. 40° 50′, Long. 3° 40′ W. The Wooster and Washington observations, seem incompatible; the latter, however, make no claim to strict accuracy. As the exlosion seen at Wooster was not observed either at Washington or Anderson it is probable that at these greater distances the disappearance was simultaneous with the separation into fragments. Such doubtless has been the case in several other instances. For example, the

* A member of the Junior Class in Wooster University was with Prof. Kirkwood.
† Letter from Prof. S. J. Kirkwood.

fragments of the meteor of August 11, 1878, seen at Titusville, Pa., were invisible at Bloomington, Indiana. If we assume, then, that as seen from Washington the point of explosion was also that of disappearance, we find by a tentative process that the observations are approximately satisfied by supposing the separation to have taken place over Tuscarawas County, Ohio, about N. 80° W. from Washington, Pa., at a distance of 70 miles, and at a height of 17 or 18 miles above the earth's surface. After the explosion the parts remained visible at Wooster until within 12 or 13 miles of the earth. The course was nearly S. W.; the true length of the entire visible track as seen at Wooster was about 85 miles; that of its projection on the earth's surface, about 60 miles. The inclination of the path to the surface of the earth was about 45°. The velocity, though uncertain, was probably greater than that corresponding to an elliptic orbit. No detonation was heard at any point of observation.

(8.) 1879, January 28, 2h. 28m., A. M., local time.—Observations at Princeton, Green Lake County, Wisconsin. Lat. 43° 50′ N., Long. 12° 13′ W.—Rev. William M. Richards, states that between 2 and 3 o'clock* on the morning of January 28, he was awakened by a sudden flash of intense light which he at first supposed to be lightning. It continued, however, for some seconds, and by the time he was thoroughly awake and ready to make observations the light had assumed a reddish tinge, somewhat resembling that of a Roman candle. He next supposed it to be a fire, but immediately found that if so, it must be out of the village. After making other conjectures, to be as quickly dismissed, he finally reach the conclusion that the light was meteoric.

"By that time," he says, "the frightful conflagration had settled down into a low pyramid of lurid light, the base extending 60° along the N. E. horizon, and the vertex having an altitude of 30°. * * * The time of the meteor's flight is very uncertain; perhaps 8 to 10 seconds. The brilliant and white light at first would indicate that the movement was from the West."†

Observations at Traverse City, Michigan, Lat. 44° 43′ *N., Long.* 8° 40′ *W.* The *Grand Traverse Herald*, of January 30, 1879, states that the accounts of this meteor by different observers were, in some respects, very conflicting; those who saw it being too much startled to observe it closely. "What *is* known is that it was an immense ball of fire, that the darkness was made light as noonday, and that a terrible explosion followed its disappearance. A night watchman who saw it explode says it flew into minute pieces like star dust. The one thing that all agree upon is the explosion. This was heard with equal clearness at Mayfield, 13 miles south of Traverse City, and at Williamsburg, 12 miles east. The effect was like that of an earthquake. Houses were jarred, windows shook, and dishes rattled upon the shelves. A swaying motion seemed to be given to the

* Mr. Richards did not notice the *exact* time. The Michigan observations give 2h. 28m.

† Letter from Rev. Mr. Richards. See also the Sci. Am. of March 15, 1879.

buildings as an upheaval and settling back. If the meteor had not been seen it would have been thought an earthquake shock."

In response to a letter of inquiry, Thomas T. Bates, Esq., editor of the *Grand Traverse Herald*, has given me the following additional statement:

"A night watch on our streets, an intelligent, cool-headed man, gives me in substance this: Was on watch; passing from due west to east; saw a great light; turned quickly and saw a ball of fire over my right shoulder; turned to left and watched it until it disappeared; when first seen it appeared about as high as ordinary rain clouds; was on a down grade close to and apparently over the bay; came from S. W. and passed to N. E.; appeared to me larger than full moon; full moon looks to me to be 18 or 20 inches in diameter; meteor appeared to pass me, and move out of sight at about the rate of speed a descending rocket has after its explosion; had a good chance to see it plainly; just after passing me a singular thing occurred; a ring of fire seemed to peel off the meteor itself, and this followed the ball of fire out of sight, but dropped a little behind it. It was perfectly distinct, and appeared to be hollow, for I could see a dark centre. Every thing was as light as day. I looked at my watch as it disappeared; it was just 28 minutes after 2 o'clock. I passed on my beat, and shortly the terrific explosion came. It shook and jarred every thing around. I immediately looked at my watch, and it was 32 minutes after 2.

"This is his report as it was given the next day, and as it was repeated to me a few days ago. I have no idea that the meteor fell into Carp Lake,* or that even a portion of it fell there. Every thing points to the correctness of Mr. Smith's report which I send you.

"Truly yours,

"THOS. T. BATES."

Charlevoix, Charlevoix County, Michigan, Lat. 45° 15′ N., Long 8° 12′ W. Willard A. Smith, Esq., editor of the *Charlevoix Sentinel* states that the meteor was seen by several persons at Charlevoix, where it appeared to be at least four times as large as the full moon; that it burst almost exactly over the village, and that parts of it were seen to fall. The ground was covered with deep snow, which was disturbed in several spots by the meteorites, though strangely enough no fragments were found. The meteor before striking the earth lighted up surrounding objects with an intensity of brightness surpassing that of sunshine, and its explosion resembled the sound of musketry. Its direction was nearly from S. W. to N. E., and the interval was very brief between the explosion and report.†

Cheboygan, Michigan, Lat. 45° 37′ N., Long. 7° 31′ W. Mr. and Mrs. Jacob Walton, of Cheboygan, both saw the meteoric light as it approached from the S. W. It lasted several seconds, and was so bright as to cast a very distinct shadow into the windows from the roof of the porch. From

*It was reported that a hole through the ice on Carp Lake had been discovered the next day, indicating that the aerolite had probably fallen into the lake.

†Condensed from a letter of Mr. Smith to Mr. Bates.

this shadow Mr. Walton estimated the greatest altitude of the meteor at about 45°. The explosion was not heard at Cheboygan.*

The preceding observations indicate that the meteor's course was approximately N. E. by N., and that it first became visible over a point not far from Lat. 44° 25′ N., Long. 9° 0′ W. The distance from Traverse city to the point at which meteoric matter is said to have fallen is about 42 miles. But the interval of four minutes between the observed explosion and the report corresponds to a distance of about 49 miles. This would make the point of explosion 26 miles above the earth's surface. The height at first appearance, if we can rely upon the rather uncertain estimate of Mr. Walton, at Cheboygan, must have been nearly 100 miles. The true length of the visible track was about 124 miles, and the length of its projection on the earth's surface, 66 miles. The time of flight is very uncertain, though the observations indicate a rather slow motion.

(9.) 1879, February 3, 11h. 30m., P. M. Indianapolis time.—This meteor is thus described by a correspondent of the Indianapolis *Daily News* for February 7:

"Raysville [Henry County], Indiana, February 4, 1879. Last night between 11 and 12 o'clock was seen, by a few citizens of this place, one of the largest and most brilliant meteors ever observed in this section. It was larger than the one seen in December, 1876, but did not last so long, being but a few seconds in view. It apparently rose from the eastern horizon, and advanced rapidly, marking its path by a stream of flame until it had almost reached the zenith, when it exploded with a dull but plainly audible report. The different parts shot earthward in various directions, but the lights of all were extinguished before they had gone very far."

(10.) 1879, February 17, 8h. 0m., P. M., Chicago time.—This meteor was observed by C. A. Kenoston, Professor of Mathematics and Astronomy in Ripon College, Wisconsin. It was first seen in the West at an altitude of about 30°. It moved slowly along the line of the two southern stars in the square of Pegasus and disappeared near the horizon without any audible explosion. It was very bright—increasingly so—and seemed to have a short tail.†

(11.) 1879, February 20, 10h. 45m., P. M.—This meteor was seen at Henryville, Clark County, Indiana, by Mr. Benjamin Vail. A brilliant train remained visible nearly a minute after the meteor itself had disappeared.‡

(12.) 1879, March 15, 3h. 53m., A. M.—This meteor was observed by a number of persons at Washington, Daviess County, Indiana. When first seen it was S. 10° W., at an altitude of 25°. It moved westward 20° and then burst into many fragments. The meteor was of a pale bluish color, but when it exploded it lighted up everything almost like daylight.

* Letter from C. S. Ramsay, Esq., to Mr. T. T. Bates.

† Letter from Prof. Kenoston.

‡ Thus briefly referred to in a letter from Mr. Vail. No further description was given.

A luminous cloud of smoke or vapor remained visible several minutes after the explosion. No sound was noticed.*

REMARKS.

As already stated, no meteorites are known to have fallen from any of the fireballs in the preceding list; although in more than one case the disappearance was followed by loud detonations, and the explosion of the meteor of February 3 took place near the zenith of the principal point of observation. It is also remarkable that the only two whose velocities could be approximately determined were almost certainly moving in hyperbolic orbits. This last mentioned fact is in harmony with the theory of Professor Von Neissl, who regards aerolitic and denotating meteors as a distinct class of cosmical bodies, differing both from comets and periodic star showers in the original velocities with which they enter the sphere of the Sun's attraction.† But not only have certain comets moved in hyperbolas but the computed velocities of at least a few bolides have undoubtedly indicated elliptic motion. This theory therefore can hardly be accepted without further confirmation.

Are meteoroids moving in hyporbolas to be regarded in general as fragments of disintegrated comets?—The discovery that the meteors of November 14, November 27, April 20, and August 10, are intimately connected with comets moving in the same orbits, has suggested that *all* shooting stars and meteoric fire-balls may have been produced by the gradual dissolution of comets or cometary clusters. It must be remembered, however, that the comets connected with these meteor streams are all periodic, and that the dispersion of their matter is due to an indefinite number of returns to perihelion. In cases of non-periodicity complete dissolution, as the result of a single perihelion passage, would be extremely improbable. We conclude therefore, that the meteor of December 30, 1878, and others with hyperbolic orbits are *not* cometary fragments dissevered by solar influence.

That some fireballs explode noiselessly, while others, apparently no larger, produce loud detonations, is a remarkable fact not hitherto explained. The fact also that explosions very often occur without being followed by the fall of aerolites seems no less mysterious. Professor Newton has suggested that aerolites are probably furnished only by such meteors as penetrate the atmosphere with relatively slow motions; those moving with great velocities being burnt up or dissipated before reaching the earth's surface. Much, however, must evidently depend on the size and constitution of the meteoroids. Small meteors (shooting stars) are entirely consumed in the atmosphere. The composition and structure of meteoric stones are very widely various. "While some are extremely hard, others are of such a nature as to be easily reducible to powder. It is not impossible that when some of the latter class explode in the atmosphere they may be completely pulverized, so that, reaching the earth in minute particles, they are never

* Letter from Prof. D. E. Hunter.

† See the Report on Luminous Meteors by a Committee of the Brit. Assoc. for the Adv. of Sci. for 1877.

discovered."* The fireballs of August 11 and December 30, 1878, as well as that of February 3, 1879, had very rapid motions, and we can perhaps best account for the non-appearance of aerolites on the theory of their complete disintegration.† The meteors, it is obvious, could not have escaped out of the atmosphere. Events of this kind are doubtless of very rare occurrence. We have, it is believed, no authenticated instance in which a fireball has escaped after approaching within 39 miles of the earth's surface.‡ Assuming this as an inferior limit and taking 100 miles as the greatest height at which such bodies become visible, it is easy to show that but one in thirty-four can continue its orbital motion.

Suggestion to Observers.

In the theory of meteors it is a matter of first importance to determine the form of their orbits. If any move in hyperbolas they must have had a proper motion in space before entering the solar system. Now the nature of a meteor's orbit is determined from its observed velocity. Unfortunately, however, the time of flight (on which the velocity depends) is generally a very uncertain element; the estimates of different observers being very discordant. Persons therefore who report such phenomena should train themselves to habits of exactness in measuring the time of visibility.

Stated Meeting, May 16, 1879.

Present, 28 members.

Vice-President, Mr. Fraley, in the Chair.

A letter of envoy was received from Mr. A. Agassiz.

A letter of invitation to the members to attend the last session, May 9th, of the West Chester Philosophical Society was received.

Donations for the Library were received from the editor of the Zoologischer Anzeiger, Leipsig; M. Melsens, Brussels; the Annales des Mines, Paris; Meteorological and Antiquarian Societies, Cobden Club, and Nature, London;

* Met. Astr., p. 65.

† The average height of shooting stars at extinction is about 55 miles; that of aerolitic fireballs and detonating meteors at the time of explosion, about 25 miles.

‡ This was the nearest approach of the great meteor of July 20, 1860. See Prof. Coffin's memoir in the Smithsonian Contributions, vol. XVI.

Science Observer, Boston; Professors Brush and Dana; New Jersey Historical Society; Franklin Institute, Medical News, Numismatic and Antiquarian Society, Philadelphia; and Mr. Horace W. Smith.

The librarian exhibited the six volumes, in elephant folio, bequeathed to the Society by its late President, Dr. George B. Wood, entitled, *Gli Edifizi di Roma e sua campagna*, &c. *By Com. Luigi Canina*, 1848, 1851, 1856.

Vols. I and II describe the Roman walls, gates, forums, basilicas, porticos, illustrated in 151 plates; Vols. III and IV describe the Roman theatres, amphitheatres, circuses, baths, aqueducts, bridges, and imperial Palatine houses, in 159 plates; and Vols. V and VI describe the antiquities of the Campagna with a large detailed map of the same in six sheets, and 139 plates of views.

An obituary notice of the late Dr. Isaac Hays was read by Dr. D. G. Brinton according to appointment April 18, 1879.

The death of Prof. Paolo Volpicelli at Rome, his natal city, at 11 P. M., April 14th, 1879, was announced by family circular.

A communication "On the Geology of the Diamantiferous Region of the Province of Paraná, Brazil, by Orville A. Derby, M. S.," was read by the Secretary. This English version of a Portuguese report prepared for the Brazilian Government was read by permission of the Director of the National Museum.

Mr. Lesley remarked that the paper just read was an important contribution to Geology for several reasons:

1. It showed the topography of the southern part of Brazil in a new light. The province of São Paulo, south of the celebrated diamond province of Minas Geraes, and the province of Paraná, south of São Paulo, were traversed by three ranges of mountains, the Sierra do Mar, or Serra Graciosa, 3000 feet high, with peaks 5000 feet high, along the coast; composed of granite, porphyries and schists, equivalent to our Blue Ridge, South Mountain and Highland range. Back of this the Serra Serrinha (or Little Mountain) over 3000 feet high, composed of highly inclined metamorphic noncrystalline schistose gneisses, red schists, and talcose or hydromica schists, probably of Cambrian and Silurian age, with a covering of pebbles of

itacolumite and other quartzites. And back of this again at the west border of the famous Campos Geraes grass plain, the Serra de Esparança, also about 3000 feet high, composed of Devonian (and carboniferous?) fossiliferous soft red sandstones resting on the shales and sandstones of the great plain, and having a bold escarpment towards the east, like our Allegheny-Cumberland backbone range. The upper part of the escarpment, however, is an outcrop of amygdaloidal and porphyritic trap 350 feet thick, and full of agates, which forms the long back or west slope perhaps all the way to the Paraná river, the border of Bolivia; and this is conjectured by Mr. Derby to be of Trias age.

2. The trend of the formations resembles that of the Atlantic border of the United States, being from west of south to east of north. But while the general geographical order is the same, namely,—Azoic, on the east along the coast, and Devonian on the west,—there are striking differences, first in its great simplicity, and secondly, in the Trias and trap lying west of the Devonian. All three ranges have escarpments towards the east. A very high (2000 feet) plateau fills in the space between the first and second ranges; and another plain sloping gently westward, and 1500 to 2000 feet above the sea, fills in the belt 100 miles wide between the second and third ranges. There is, therefore, a general uptilt of this part of Brazil towards the east; higher and higher rocks coming in as one goes west, and the whole slowly settling into the great central plain of South America, as ours do under the plain of the Mississippi Valley.

3. The drainage system has some striking features of resemblance to that of the United States when we consider the short rivers which flow eastward into the Atlantic, and the long rivers, like the Upper Ohio, Kenawha and Tennessee, which flow through the Allegheny Mountains *down dip*, westward into the Mississippi. For Mr. Derby describes four main rivers: 1. The short Ribeira which alone flows east, through the granite range, into the Atlantic; 2. The long Iguassu on the south, and 3, the long Paranapamena on the north, both of which drain the first high plateau and flow in opposite directions from one another, and then turn and cut westward into the face of and through both escarpments, and through the second plain; and 4, the long Ivahy, between them, which cuts across the second plain and third escarpment westward, also into the Paraná.

4. Mr. Derby shows that the pot holes of the Tibagy (a branch of the Paranapamena) got their diamonds and other crystals not *directly* from any older formation than the Devonian, for the Tibagy drains nothing but Devonian country. But again he shows that the diamonds, &c., must have been set free by the erosion of the Devonian sandstones as pebbles or sand-grains or fossils; for the Devonian sandrocks are not in the least metamorphosed. The diamonds must therefore have been originally derived from much older itacolumite rocks, &c., out of which the Devonian rocks themselves were constructed by erosion and deposition.

Dr. LeConte, at the request of Mr. Dubois of the U. S. Mint, exhibited a very fine specimen of laminated native

copper from the Calumet and Hecla mine, Lake Superior, and explained its appearance on the supposition that it had been subjected to a sliding pressure between the two walls of a fissure, thus representing a phase of slickensides.

Prof. Cope presented a paper entitled, "Notes on some landshells of the Pacific slope, by J. G. Cooper, M. D.

Mr. Lesley exhibited a slab of limestone full of Trenton trilobites, given nine years ago to Dr. Isaac Lea by Mr. S. Emlen Sharples, of Bucks County, Pennsylvania, who took it from the walls of a limekill at a quarry near Greenville, on the north edge of the belt of limestone rocks (enclosed in Mesozoic) 3000 feet thick, and dipping northward.

The slab is given by Dr. Lea to the Museum of the Geological Survey, and is valuable in evidence of the presence of the Trenton formation in a range over which discussions have been and are still taking place. It is of especial interest just now in view of the late publications of Prof. J. D. Dana, on the new localities of Trenton fossils around Poughkeepsie, east of the Hudson river.

The minutes of the last meeting of the Board of Officers were read.

Pending nominations Nos. 878 to 883, and new nomination No. 884 were read.

The Treasurer moved the following resolution, which was adopted:

Resolved, That the Treasurer be authorized to execute under the seal of the Society a transfer of the certificate of $5000 of the U. S. six per cent. loan held by them, and called in by the Secretary of the Treasury.

Dr. LeConte's resolutions of May 2, being in order of business, it was, after debate, on motion of Mr. McKean, resolved that the consideration of the resolutions be postponed to the second regular meeting in October next.

On motion, leave was given to Mr. Briggs, and Dr. Barker, and to Mr. Britton to withdraw their reports read at the last meeting.

On motion, an appropriation of $10 was made for subscribing to the life of Dr. William Smith, by H. W. Smith,

one volume of which was exhibited, and the other promised in August next.

The meeting was then adjourned.

The Geology of the Diamantiferous Region of the Province of Paraná, Brazil. By Orville A. Derby, M. S. (English Version.)

(Read by permission of the Director of the Brazilian Museum before the American Philosophical Society, May 16, 1879.)

A portion of the ancient Capitania of São Paulo, now the province of Paraná, has long been known to be diamantiferous, but as no extensive washings have ever been undertaken, and as the gems thus far found have been of small size, although of good quality and color, only very little attention has been attracted to this region, in comparison with the more fully explored diamond fields of the provinces of Minas Geraes and Bahia. During a recent excursion in Paraná, I was able to make some observations on the geology of the region in question, and on the mode of occurrence of the diamonds.

The province of Paraná lies between São Paulo on the north, and Santa Catharina and Rio Grande do Sul on the south, and extends from the Atlantic to the river Paraná, occupying about six degrees of longitude and three of latitude. Topographically it is divided into two very distinct regions: a mountainous region along the coast, extending about 100 miles inland, and a plateau region, occupying the central and western portions of the province. The first or mountainous region constitutes a distinct geological area, while the plateau portion is divided into two grand geological provinces. Strictly speaking, the whole province, with the exception of a coast belt from ten to twenty miles wide, is a plateau, the coast mountains, constituting a part of the great Serra do Mar system, but known in this province by the beautiful and appropriate name of the Serra Graciosa, rising abruptly from the coast belt, and forming the margin of a plateau, from 800 to 1000 metres in height. In the northeastern part of this great plateau, an interior range of mountains, a continuation of the Paraná-piacaba range of São Paulo, rises above the general level, but dies away towards the south. The coast belt, the Serra do Mar, and the eastern portion of the great interior plateau, whether mountainous, as in the north, or nearly level, as in the south, have the same general geological characters, and may properly be united together in what I will designate as the first or mountainous or, geologically speaking, the metamorphic region. The topography of this region, in the more mountainous portions, is bold and abrupt, with picturesque peaks, rising to a height of about 1500 metres above the sea, and 600 to 700 metres above the river valleys and the more level portions. The latter are, in general, moderately undulating prairies,

with strips and patches of forest. In the southern portion of the province one such area, of considerable size, extends from the Serra do Mar to the margin of the second region, and reaches northward to beyond the capital, Curityba. Another and much smaller area exists to the west of the second range of mountains, in the north of the province, about the city of Castro. This last is generally included in the second region, under the name of the Campos Geraes, but geologically it has nothing in common with those campos, and belongs to the first region.

The rocks of this region are all metamorphic, the beds being highly inclined, with a general strike E. N. E. Along the coast and in the Serra do Mar granite, porphyritic and schistose gneisses occur, as in the corresponding region of the province of Rio de Janeiro, with an abundance of igneous rocks, including diorite, porphyry and a compact variety with a basaltic structure. In the plains about Curityba epidotic rock occurs abundantly, with schistose gneiss; while farther west the latter is associated with metamorphic, noncrystalline, red schists, which are either talcose or hydromica, and with red, metamorphic porphyry, which is a more metamorphosed portion of the same schists. In the plains about and to the west of Curityba a thick deposit of decomposed material covers the rock and good exposures are rare. The rocks seen *in situ* are those above mentioned, but an abundance of pebbles of itacolumite and other varieties of quartzite attest the existence of other rocks in the vicinity.

Unfortunately I was unable to visit the northern mountainous portion of this region, about the head-waters of the river Ribeira, which is by far the most interesting part of the metamorphic belt. In the western margin of this district, which is known by the general name of Assunguy, I found the red schists and porphyries, above mentioned, extensively developed, with beds of white marble and iron ore. From the specimens and information I was able to obtain from this region, it appears to be very rich in marbles, iron ores and auriferous rocks. From about fifteen miles north of Curityba, I saw a greenish serpentine marble, identical with that associated with the same red schists near Sorocaba, province of São Paulo, and from other portions of the Assunguy region, I saw specimens of itacolumite and of the peculiar auriferous, ferruginous quartzite called Jacutinga, so characteristic of the metamorphic region of Minas Geraes. These specimens, and the few observations I was able to make, confirm the opinion I had already formed, that the non-crystalline metamorphic series, composed of quartzites (itacolumite, itabirite, jacutinga, etc.), talcose (hydromica?) schists and marbles,* so characteristic of the interior of the provinces of Bahia and Minas Geraes, extend in a continuous belt to the southward, probably as far as Rio Grande do Sul, presenting everywhere the same essential characters.

I have elsewhere† presented reasons for referring the crystalline meta-

*The crystalline marbles form a very subordinate part of the series, which, for convenience, I call non-crystalline, to distinguish it from the older crystalline series, composed of gneisses, etc.

†Proceedings, American Philosophical Society, page 161 above.
Archivos do Museu Nacional, Rio de Janeiro, Vol. II, 1878.

morphic series to the Archean, and the non-crystalline series to the Lower Silurian or Cambrian, a classification in which I but follow my esteemed friend and teacher, the lamented Prof. Hartt.

Going west from Curityba, at a distance of about thirty miles, an abrupt escarpment, called the Serrinha, or Little Serra, is met with, rising to an elevation of 1040 metres, or about 200 metres above the plateau of Curityba, which it completely dominates. This escarpment extends across the province in a general north-south direction, being, however, somewhat irregular and zig-zag towards the north, where it becomes, in a measure, confounded with the higher lands of the Assunguy region, which surpass it in elevation. In consequence of this it does not separate so completely as in the south the various systems of drainage.

This escarpment is composed, in the lower part, of the inclined metamorphic beds above described, capped by massive horizontal beds of coarse, friable, white sandstone, which rise everywhere to the same level, but vary in thickness from 20 to 100 metres, owing to the irregularities of the surface upon which they were deposited.

The Serrinha forms the eastern margin of the second region, the far famed Campos Geraes. This is a vast grassy plain, extending westward about 100 miles, with a gentle inclination towards the west, where the elevation of the highest portions becomes reduced to from 850 to 900 metres. The surface along the margin is almost perfectly level, but the innumerable streams, fed by thousands of springs and by torrential rains, soon cut themselves deep valleys, descending in the western portion of the region to an elevation of 600 metres, rendering the surface more and more undulating, as one enters the Campos. In a broad zone in the western part, there are, in addition to the irregularities due to denudation, others of greater consequence, caused by numerous immense dykes of diorite.

The character of the rock changes also in going westward, the sandstone becoming finer and tending to give way to beds of shale, which occur interstratified with the sandstone, in such a manner as to show that they belong to the same formation. In general it may be said that, in the west, as a rule, the lower portion of the formation is composed of shales and shaly sandstones, the shales in the extreme west becoming charged with silicious and calcareous concretions, and containing a few subordinate beds of a peculiar, silicious, oölitic limestone. This shaly portion is wholly, or in part, overlaid by soft sandstone, which to the eastward is the predominant formation. The sandstone appears to cover the shales over the entire region, but on this point I cannot form a positive opinion, before making a detailed study of the fossils collected, as it is possible that, in the wooded limestone region, I may have been deceived in regard to the identity of the sandstone that occurs there, with that of the open campos, further east. The rock is everywhere charged with pebbles, and often, in limited regions, changes to a pudding stone or conglomerate. In a ravine near Ponta Grossa, I found such a conglomerate, containing boulders a foot and a half in diameter, of metamorphic rocks, such as gneiss, syenite, quartzite,

etc. The most interesting is a boulder of metamorphosed conglomerate, containing rounded pebbles, the size of one's fist, of the rocks above-mentioned, united by a metamorphosed, silicious cement. These boulders undoubtedly indicate the neighborhood of some high point of the original surface of the underlying metamorphic rocks, which, before being buried, formed an island in the sea, in which the deposits of shale and sandstone were being laid down.

In the portions of this region where the sandstone is the prevailing surface rock, the soil is poor and sandy, supporting only grasses and, on the slopes, small patches of forest, in which the Araucarian pine occurs in great abundance. This tree is also extremely abundant on the metamorphic plateau of Curityba. The shaly portions of the region have a somewhat better soil, but are still poor, in the eastern and central parts. Going westward, the soil improves, the beautiful open campos giving place to others with scattered pines and an abundance of shrubs, and these in turn, in the extreme west, where the shale is more varied in character, and where diorite and calcareous rocks are abundant, are replaced by luxuriant forests, showing the superior quality of the soil.

The geological age of this sandstone and shale has never been satisfactorily determined. The first light on the subject was thrown by a few fragmentary fossils, discovered by Mr. Luther Wagoner, Assistant of the Geological Commission, in 1876, and determined by Mr. Rathbun and myself to be Palæozoic, and probably Devonian. A few months ago, I found in the province of São Paulo, in a cherty limestone, identical with that above mentioned, a few obscure Lamellibranchs, belonging to Devonian or Carboniferous types. In my last excursion I visited the localities discovered by Mr. Wagoner, and had the good fortune to find more perfect specimens. From a bed of shale, intercallated in the sandstone, at Ponta Grossa, close by the conglomerate locality above mentioned. I found a species of Ophiuran, a few badly preserved Lamellibranchs, and species of *Lingula*, *Discina*, *Spirifera*, *Rhynchonella*, *Streptorhynchus and Vitulina*, strongly resembling, and probably identical with, those of the Devonian of the Amazonas. The *Spirifera*, *Streptorhynchus* and *Vitulina* are particularly well-marked Devonian types, the former being probably identical with *S. duodenaria*. In the cherty limestone at Ivahy, I found a number of species of Lamellibranchs, some of which are identical with those of São Paulo, but I could not, in the field, give them the study required to determine with certainty whether they belong to the Devonian or Carboniferous. Fragments of *Lepidodendron* also occur in the same rocks.

As above remarked, the elevation of this second region diminishes somewhat towards the west, where the heights, including the diorite ridges, rise to 850 or 900 metres, although, owing to the excessive deepening and widening of the numerous valleys, the general level is somewhat lower. From this level rises a second escarpment, known as the Serra de Esperança, to a height of 1040 metres. On the steep slope there is seen, in ascending, a considerable thickness of soft, red sandstone, overlying the shales

and sandstone of the second region, and above this a bed, 100 metres or more in thickness, of amygdaloidal and porphyritic trap, apparently a kind of trachyte. The amygdaloid is full of beautiful agates. This second escarpment is the beginning of the third geological region, the topographical features of which are very similar to those of the second or Campos Geraes region,—that is, produced by denudation on horizontal beds. The escarpment extends entirely across the province, in a north-south direction, and into the province of São Paulo, where I have recognized the same rock, in the margin of the plateau, west of the Piracicaba river. South of the river Iguassú, I am informed by Mr. Luis Cleve, a very competent observer, that it bends eastward, under the name of Serra de Espigão, and extends as far as the Serra do Mar. Prof. Hartt had already observed that the Serra do Mar, in Santa Catharina, is capped by phorphyritic trap. It is probable, therefore, that these rocks cover the greater part of the interior of that province, as well as the neighboring portion of Rio Grande do Sul, in which agatiferous trap is common. A portion of the Republic of Uruguay probably belongs to the same formation. To the west the country is unexplored, but from the scanty information I could obtain, it seems probable that the trap formation extends to the river Paraná.

The surface of this region is, in general, a heavily wooded plain, but has several extensive campos, the most important ones being those of Guarapuava, which unite, to the south, with the extensive campos of Rio Grande do Sul. There appears to be a slight inclination towards the Paraná, and the river valleys being deep, present high steep slopes, that have been dignified by geographers, as well as the common people, as mountains. In point of fact, no true mountains exist in the province, outside of the metamorphic area.

No very definite data exists for determining the geological age of this enormous outflow of trap. It is certainly later than the Devonian, and is most probably Mesozoic. In lithological characters both the trap and the red sandstone, which appears to be associated with it, and to be distinct from the underlying Devonian series, resemble in a striking manner the Triassic rocks of eastern North America.

The drainage of the province is determined by the above described topographical features, and is principally toward the Paraná, only one large river, the Ribeira, flowing directly to the Atlantic. This river rises north of Curityba, in the mountainous Assunguy region, and flows northward, into the province of São Paulo, breaking through the Serra do Mar, above the city of Iguape. Some of its tributaries flow down the slope of the Serrinha, and have cut ravines, indenting the margin of the sandstone region, but can hardly be said to drain any part of the Campos Geraes. In the same metamorphic region, between the Serra do Mar and the Serrinha, rises the principal river of the province, the Iguassú, which flows first southward and then westward, traversing the second and third regions, to empty into the Paraná. Passing over several almost unknown rivers, belonging exclusively to the third region, we come to the Ivahy,

which rises in the wooded western portion of the second region, flows for some distance northward, skirting the base of the Serra de Esperança, and finally turns westward, entering the third region, and traversing it to the Paraná. In the north, forming a part of the northern boundary of the province, is the large river Paranapanema, which, like the Iguassú, rises in the metamorphic region and traverses the two others, receiving from the province the Itararí, Rio do Cinzas and Tibagy. The latter is, *par excellence*, the river of the Campos Geraes, in which it rises and flows, to within a short distance of its mouth, where it enters the third region. It receives from the north the Pitanguí and Yapo, both of which rise in the metamorphic region, about Castro, and enter the sandstone region by deep cañons.

The diamantiferous region is principally in the valley of the Tibagy. Its tributaries, the Yapo and Pitanguí, also contain the gems, but are supposed to be less rich than the main river, perhaps because of insufficient examination. Fine diamonds are also said to have been found in the Rio de Cinżas. As far as I was able to learn, they have never been found in the Iguassú or Ivahy, although I see no reason why they should not occur, at least in the former river.

The gems occur in the sands of the river, in the numerous pot-holes, and also in gravel banks, known as dry washings, situated in the campos, at a greater or less elevation above the river. Near the village of Tibagy, are two of these dry washings. One is in a depression of the Devonian shale, in the valley of a small stream, and is only a few metres above the level of the river. It may therefore be supposed to have been deposited by the river, or by the stream that now cuts through the deposit. The section presents below a very irregular deposit of pebbles and sand, a few centimetres in thickness, which is the part washed. Above this are three or four metres of coarse, variegated sand, with pebbles scattered irregularly through the bed, which shows very irregular lines of deposition, as if deposited in an eddy. Portions of this bed have been cemented by oxide of iron, forming curious, corrugated sheets, globes, and irregular masses, of extravagant form. On top is about a metre and a half of dark-red, structureless clay. The other washing is on a hill side, near the top, at an elevation of about twenty metres above the bed of a small stream, which flows along the base of the hill, and empties into the river, at an elevation of about 100 metres below the mine. The deposit has evidently been laid down under water, but it can scarcely be attributed to any of the present streams. It also rests on Devonian shale, fragments of which are scattered abundantly through it, and consists of a bed, about three metres thick, of sand and pebbles, in which diamonds are irregularly distributed. Above this are about six metres of structureless, red clay, like that of the first washing.

The pebbles in both these washings are well rounded, and consist mainly of quartz and of quartzose rocks, with pebbles of gneiss, and of various other metamorphic and igneous rocks. The red clay continues nearly to the top of the hill, which is a long ridge, with moderate slopes, and extends for a

considerable distance horizontally, but whether it is everywhere underlaid by the diamantiferous gravel or not, I cannot state. Other washings have been opened, some twelve or fifteen miles below Tibagy, and it is probable that there are many other localities in which diamonds may be found.

As I saw no work in progress, I could form no idea of the richness of these mines. The diamonds are said to be rare, and small and poor, in comparison with those found in the river. The workings have been conducted on a very small scale and very carelessly, so that, although the mines are certainly not extremely rich, it is impossible to affirm that they would not repay better, and more systematic management. A small quantity of gold also occurs in these washings, and this metal is quite generally distributed throughout the region.

In the river, the best stones are found in the deposits in the pot-holes, which contain gravel, firmly cemented by ferruginous matter. Rarely pot-holes are found with a very hard, bluish cement, and these are reported to contain the most diamonds, which are of the best quality both as regards size and perfection. Not having seen this cement, I can form no idea of its character. The miners note as a curious fact, that in a group of pot-holes close together, one may have the bluish cement, while all the rest have the ferruginous, the pebbles of the one being quite different from those of the others.

Many of the stones shown me were broken and worn, but a fair proportion were perfect crystals. The largest ones I saw were about the size of a small grain of corn, but were irregular and broken. The most valuable stone found here, of which I could obtain an authentic account, was sold for a conto of reis ($500). The stones are in general of good color and brilliancy.

Coming now to the question of the origin of the diamonds, it seems to me to be very evident that they are washed out of the Devonian sandstone. As already remarked, the Tibagy is almost exclusively a river of the Devonian plain. The lower portion, in the trap region, is not known to be diamantiferous, and if it is, since the stones occur throughout the whole course of the river, before it enters the trap formation, the latter may be eliminated from the problem. There remain then the Devonian rocks and the diorite. Having passed around the head of the river, and crossed it at three different places, I have become satisfied that these are the only rocks that come to the surface, to the eastward of Tibagy, that is to say, in the diamantiferous region. It is of course possible that the river may have cut down, in certain places, to the underlying metamorphic rocks, but of this there is no evidence, and it is not probable that any considerable area of such rocks are exposed, or if so exposed that it could have furnished diamonds to so wide-spread a region. Two considerable tributaries, the Yapo and the Pitanguí, flow from the metamorphic region, and might be supposed to have brought the diamonds from the rocks cut through in that region, but I was unable to obtain any notice of diamonds, found in those rivers, before entering the sandstone district, and the Tibagy is diamantiferous above, as well as below, its confluence with them.

PROC. AMER. PHILOS. SOC. XVIII. 103. 2G. PRINTED JUNE 10, 1879.

The diorite can scarcely be supposed to have furnished the gems, not alone on account of the nature of the rock, but because in the upper part of the valley, where diamonds are not uncommon, diorite is extremely rare, if it occurs at all, and because the pebbles which always accompany the gems, certainly do not come from the diorite. This last has most probably furnished, by decomposition, the red clay, above the gravel at Tibagy. The only other rocks which, as far as I observed, could have given such a clay, are those about Castro; but it would be difficult to account for its transportation from there to Tibagy, while large dykes of diorite are common near the latter place.

The secondary origin of the gravel is not far to seek. The sandstone is everywhere full of pebbles, and on every slope where this rock is exposed the surface is strewn with gravel, set free by disintegration. The primary origin of the pebbles is equally clear; they, in common with all the material of the Devonian beds, are derived from the metamorphic series. That the diamonds have the same primary origin can hardly be doubted, as they cannot be supposed to have been produced in the sandstone, which does not show the slightest sign of metamorphism or of crystallization of any kind. That the diamond must have originated in some series rich in crystals is evident from the fact, that it is always accompanied by a variety of crystals, called by the miners *informations*. I have not had an opportunity of determining those of Tibagy, which do not differ materially from those already described from Bahia and Minas Geraes.

It may then be regarded as extremely probable, if not absolutely certain, that the diamonds originated in the metamorphic series; that, during the Devonian age, they were washed out and redeposited in the sandstone, from which they have been again extracted, to find their third resting place in the sand banks and pot-holes of the river, and in the gravel deposits of the campos. May we not suppose that the rare patches of gravel, with blue cement, are nests formed in the sandstone and laid bare by the formation of pot-holes?

As to what portion of the extensive metamorphic series constituted the original matrix of the diamond, I could obtain no data in Paraná. The evidence on the subject, which is being slowly accumulated, tends apparently to the confirmation of the old idea, that it belongs to some part of the itacolumite series.

After my studies in Paraná, it seems to me probable that the extensive high sandstone plateaus of Central Brazil, which we have been accustomed to consider of Tertiary age, are in reality much older, and probably Palæozoic. It is yet too early to form a decided opinion respecting them, but if my suspicion regarding their age proves correct, we can explain the course of geological events in Brazil much more satisfactorily than at present.

The lower plateaus, of almost precisely similar topographical and lithological character, along the coast and on the Amazonas, are certainly later than the Cretaceous; but none of those, whose age can be positively determined, rise much above 1000 metres, and the higher plateaus of the interior have been referred to the Tertiary, solely on resemblances in lithological characters which, in Brazil, are peculiarly deceptive and untrustworthy.

Obituary Notice of the late Isaac Hays, M.D. By Daniel G. Brinton, M.D.

(*Read before the American Philosophical Society, May* 16, 1879.)

The subject of the present memoir, Dr. Isaac Hays, had been at the time of his death, a member of this Society for very nearly fifty years, his name first appearing upon its rolls in 1830. For many years he was also one of its most active members, and in the published volumes of our Proceedings which embrace the period previous to 1850, his name frequently recurs. Most of the subjects which he brought before the Society, related to medical science, and especially those portions of it connected with the physiology of vision and ophthalmic surgery. But he did not confine himself to professional topics. I find, on looking over the earlier numbers of our Proceedings that he took considerable interest in geology, particularly in the remains of the gigantic mammals preserved from the post-tertiary period. About 1840, a number of such remains were collected in Missouri by Dr. Koch, and subsequently exhibited in this city and London. An active discussion arose among palæontologists as to their classification. Besides, the mastodon, the *Elephas primogenius*, and the mammoth, they distinctly proved, so one party maintained, the former existence of another species of mastodontoid animals belonging to the class *Proboscidæ*, to which was given the name *Tetracaulodon*. Dr. Hays sided with this party, and in addition to many verbal statements embodied in the Proceedings, he published in the Transactions a paper on the teeth of the mastodon, evincing in its preparation a most careful study of his theme. That later investigations have disproved his position, detracts but little from its merit; for the abstract correctness of a scientific theory is of less importance than the honesty and ability with which it is advocated. At various periods Dr. Hays served on the Committee of Publication, and the Council, and was Curator.

At the time Dr. Hays was elected to this Society, he was thirty-four years of age. He was born July 5, 1796, in this city, his father residing at that time on Chestnut street below Third. His education had been first at the Grammar school kept in those days by Samuel Wylie, next at the University of Pennsylvania, whence he was graduated, A. M., in 1216; and finally as a medical student in the same institution whence he received the degree of M. D., in 1820. His preceptor was the eminent Dr. Nathaniel Chapman, celebrated not less for his wit than for his professional skill.

In early life Dr. Hays was much interested in natural science, and even before his graduation in medicine, he joined, in 1818, the Academy of Natural Sciences. With its history and success, he was identified for more than half a century. From 1865 to 1869 he was its President, and in many other official capacities actively aided its progress and influence.

His sympathies with the advance of general science led him to unite with others in the organization of the Franklin Institute. He was one of its original members, and for a number of years its Corresponding Secretary.

To his activity much of the success of that prosperous institution can justly be ascribed.

As a physician, Dr. Hays studied and practiced his profession in a spirit of liberal culture and honorable feeling. The special branch which he cultivated was ophthalmology, and for a long time he stood first in that department in this city. He was one of the earliest to detect the pathological condition known as astigmatism, and the case which led to his discovery of it was reported to this Society.

His professional life was not confined to the care of his large practice, but extended to the relations of medical men to each other and to the public. Thus he was a member of the Convention which organized the American Medical Association, and of that which led to the formation of the State Medical Society of Pennsylvania. As Chairman of the Committee of the former body to draw up a Code of Ethics, he was mainly instrumental in collating and reporting the code which has since been universally adopted throughout this country, and in some parts of Europe. He was also Chairman of the Board of Publication, and Treasurer of the Association for several years.

In September, 1835, he was elected a member of the College of Physicians and for a number of years was its Senior Censor. He was also Chairman of its Building Committee, and it was largely through his endeavors that the commodious structure at the corner of Thirteenth and Locust street, was erected for the College.

Dr. Hays literary labors include an edition of Wilson's Ornithology, 1828; Arnott's Elements of Physics, 1848; Hoblyn's Dictionary, 1846; Laurence on Diseases of the Eye, 1847, and some other medical works; but he is best known in this connection as the editor of the American Journal of the Medical Sciences, with which he was actively connected from February 1827, until his death. The ability and judgment he displayed in this task met with full recognition from the profession, both in this country and Europe, and the Journal has for half a century been recognized the world over as unsurpassed by any other medical periodical of its class in this country.

Advancing age led to his retirement from active practice in 1864–5, but he continued his literary and scientific labors, with unimpaired faculties and undiminished interest in the progress of knowledge to the last.

In conclusion, I may add that Dr. Hays married in 1833, and at his death left four children, one of whom is a prominent member of the same profession, and has succeeded to his father's position as editor of the American Journal of the Medical Sciences.